Tongue/Powder/Rosebud TMDL Modeling Committee Meeting

August 10, 2004

Discussion Topics

- Part 1 - Process Updates
- Part 2 - Responses to Modeling Committee Input
- Part 3 – Model Application
- Part 4 – Updated Impairment Status
  - EC/SAR
  - All others
- Part 5 – Predictive Simulation Results
- Part 6 – Questions/Comments/Wrap-up

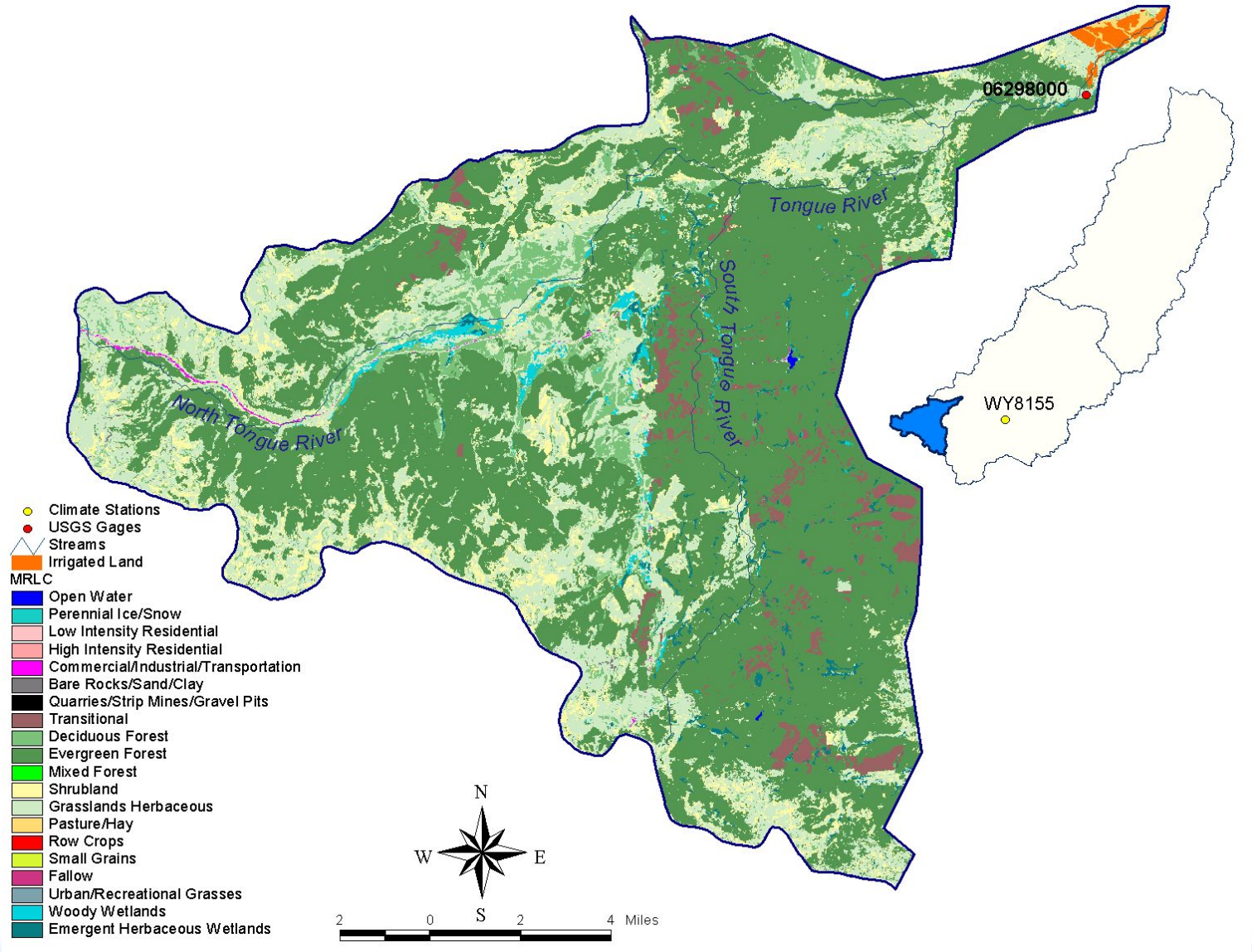
Part 1 – Process Updates

Part 2 – Response to Committee Input

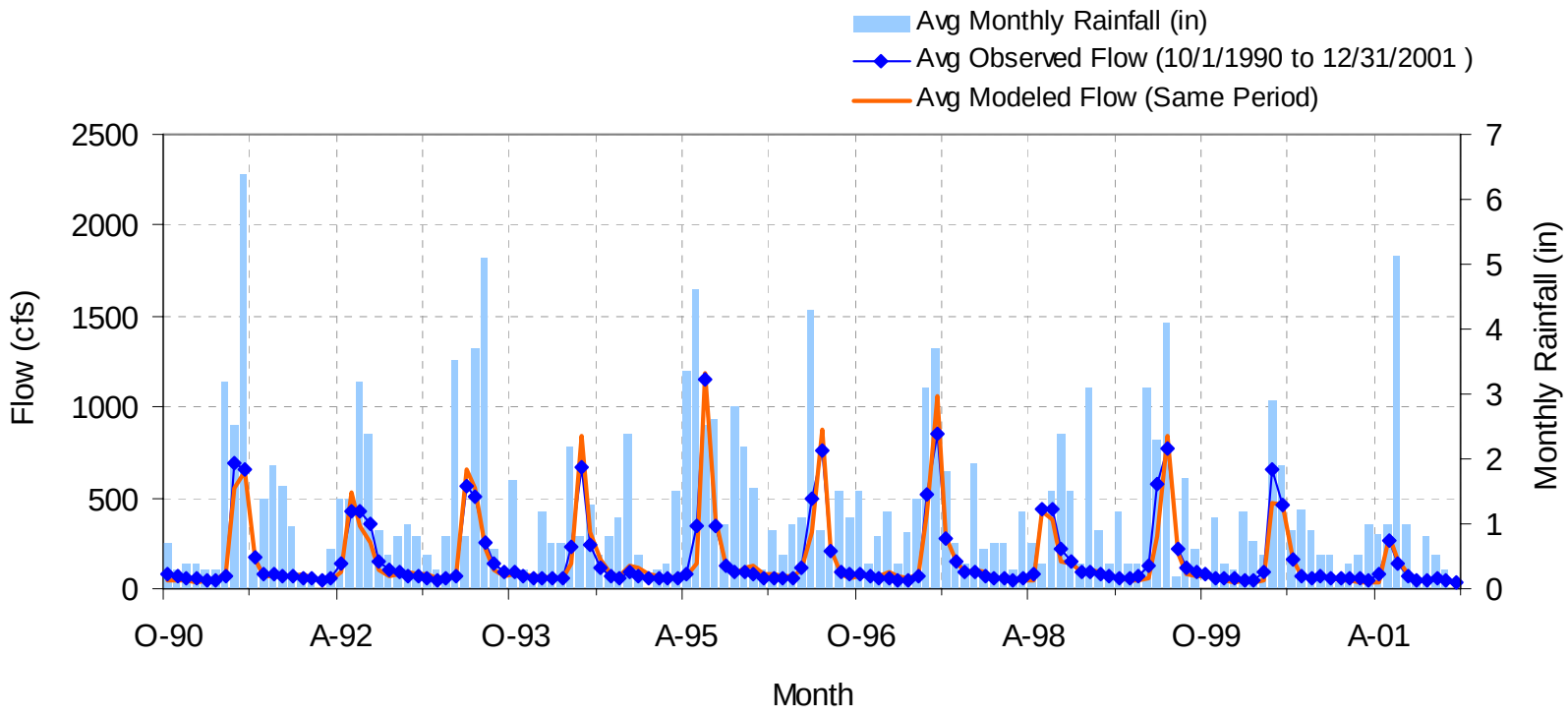
Improved Snowmelt Results

- Model previously not effectively dealing with snow melt
  - Typically melted too early
- Committee made several recommendations
- Obtained and used SNOTEL melt data as direct input to model (rather than trying to predict)
  - Results improved considerably

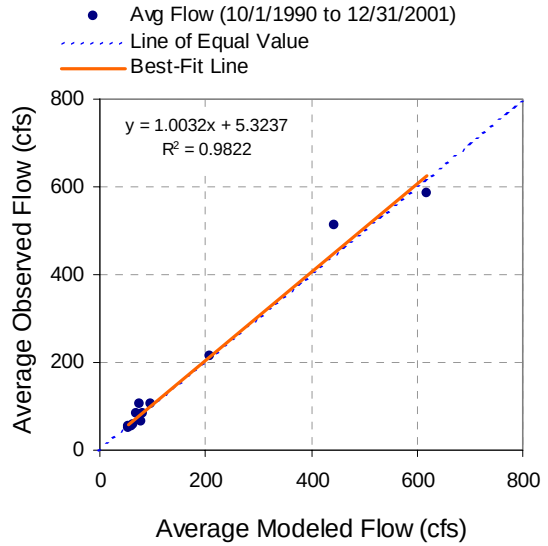
Tongue River near Dayton, WY:

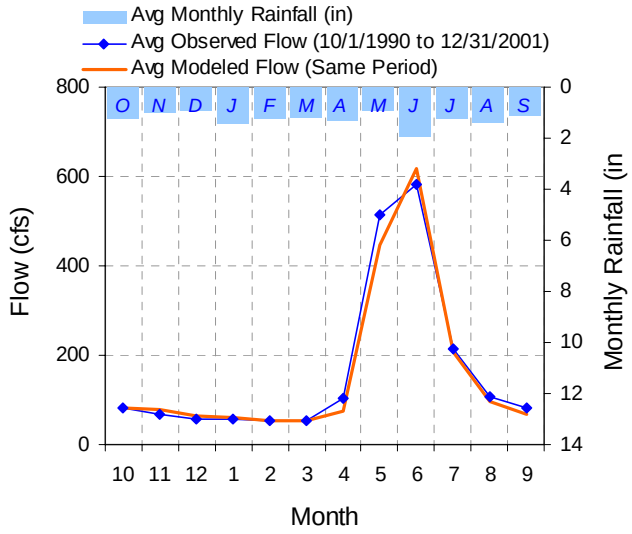


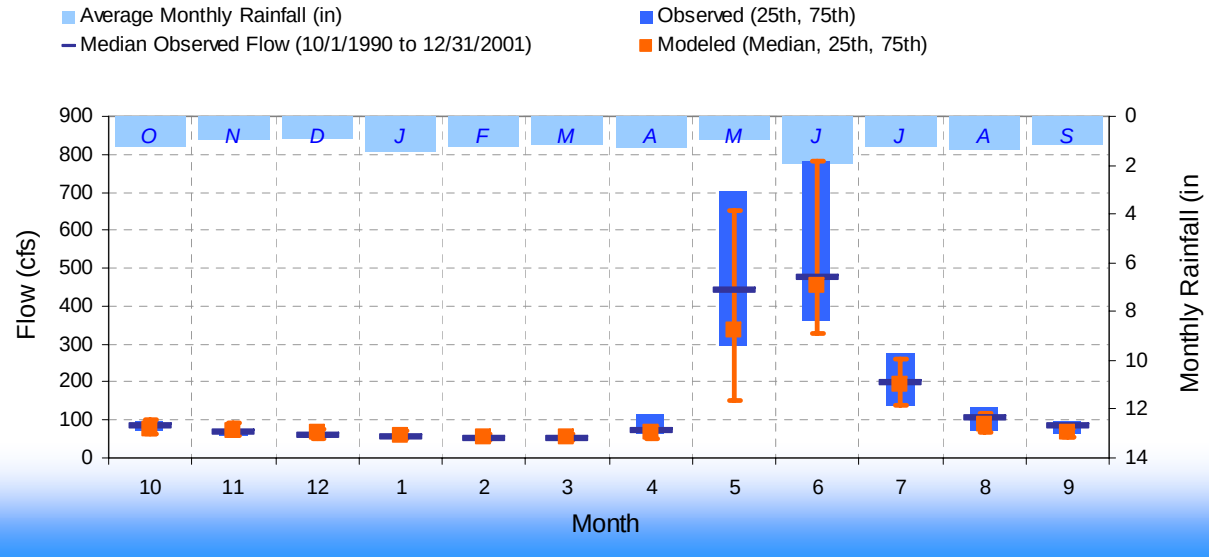
Tongue River near Dayton, WY: Hydrologic Time Series



Tongue River near Dayton, WY: Hydrologic Composite





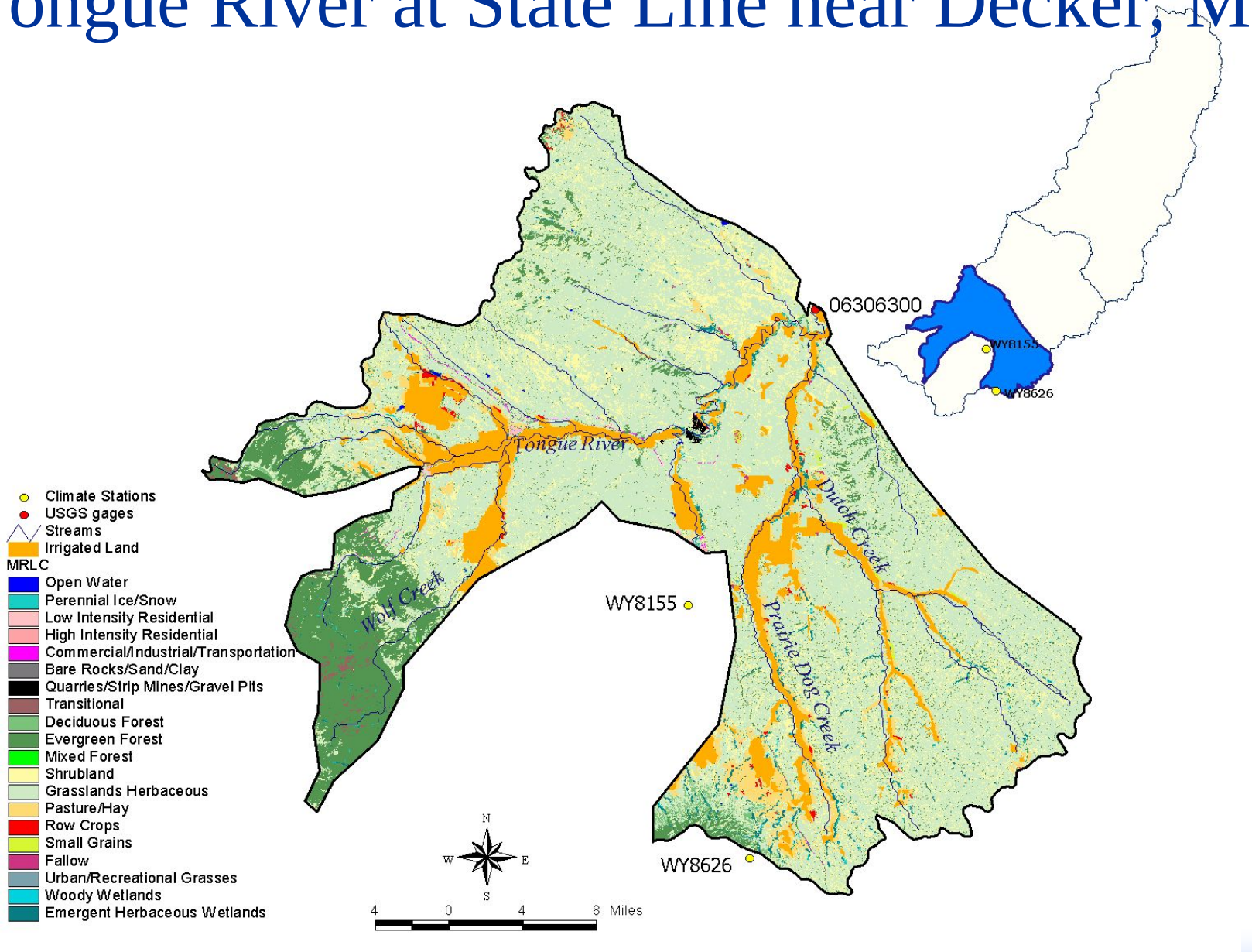


Tongue River near Dayton, WY: Hydrologic Statistics

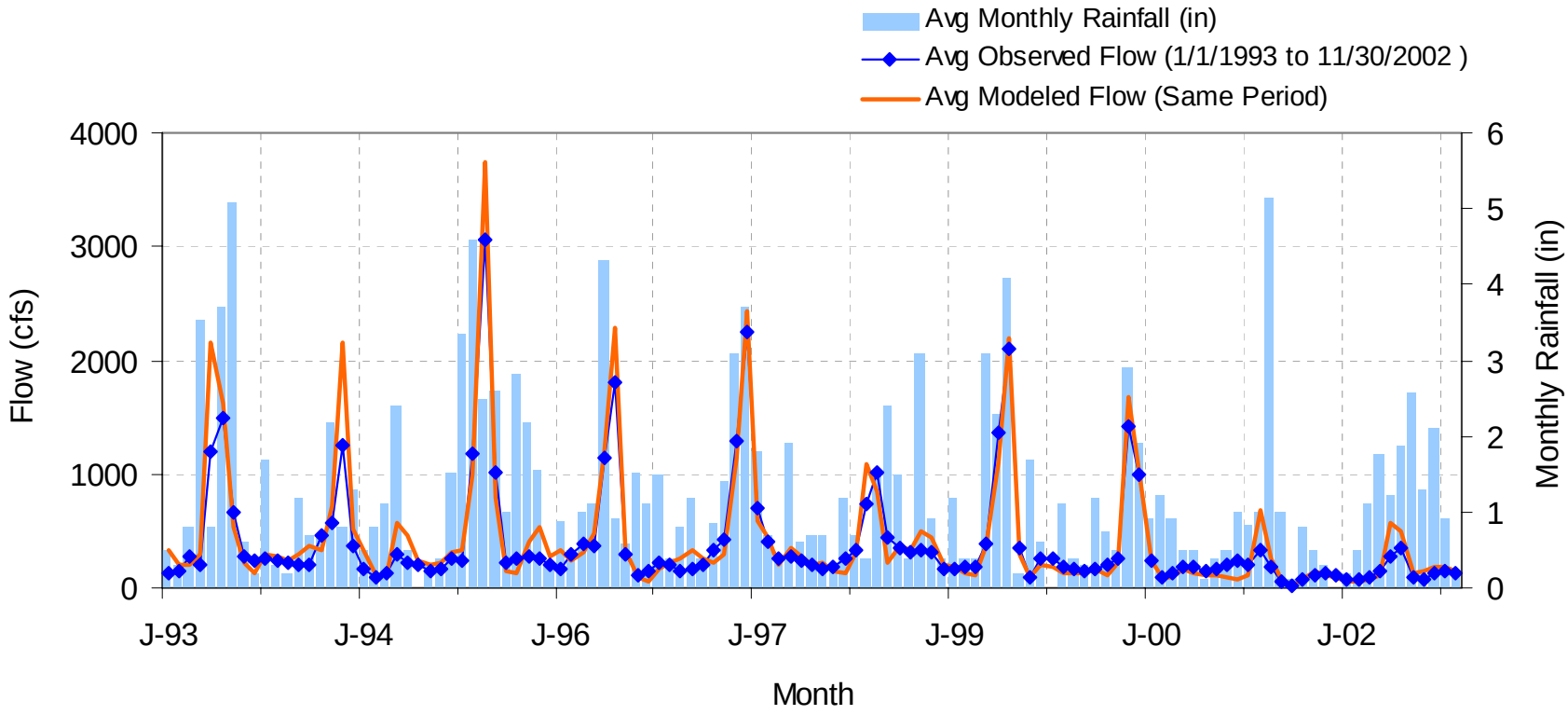
LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 30 11.25-Year Analysis Period: 10/1/1990 - 12/31/2001 Flow volumes are (inches/year) for upstream drainage area		**USGS 06298000 TONGUE RIVER NEAR DAYTON, WY** Sheridan County, Wyoming Hydrologic Unit Code 10090101 Latitude 44°50'58", Longitude 107°18'14" NAD27 Drainage area 206 square miles	
Total Simulated In-stream Flow:	**64.62**	Total Observed In-stream Flow:	**66.97**
Total of simulated highest 10% flows:	**30.79**	Total of Observed highest 10% flows:	**30.33**
Total of Simulated lowest 50% flows:	**11.41**	Total of Observed Lowest 50% flows:	**11.60**
Simulated Summer Flow Volume (months 7-9):	**12.66**	Observed Summer Flow Volume (7-9):	**13.69**
Simulated Fall Flow Volume (months 10-12):	**8.19**	Observed Fall Flow Volume (10-12):	**7.70**
Simulated Winter Flow Volume (months 1-3):	**5.61**	Observed Winter Flow Volume (1-3):	**5.37**
Simulated Spring Flow Volume (months 4-6):	**38.16**	Observed Spring Flow Volume (4-6):	**40.21**
Total Simulated Storm Volume:	**8.50**	Total Observed Storm Volume:	**10.29**
Simulated Summer Storm Volume (7-9):	**1.09**	Observed Summer Storm Volume (7-9):	**1.39**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	-3.65	10		
Error in 50% lowest flows:	-1.68	10		
Error in 10% highest flows:	1.48	15		
Seasonal volume error - Summer:	-8.14	30		
Seasonal volume error - Fall:	6.06	30		
Seasonal volume error - Winter:	4.17	30		
Seasonal volume error - Spring:	-5.39	30		
Error in storm volumes:	-21.03	20		
Error in summer storm volumes:	-27.50	50		

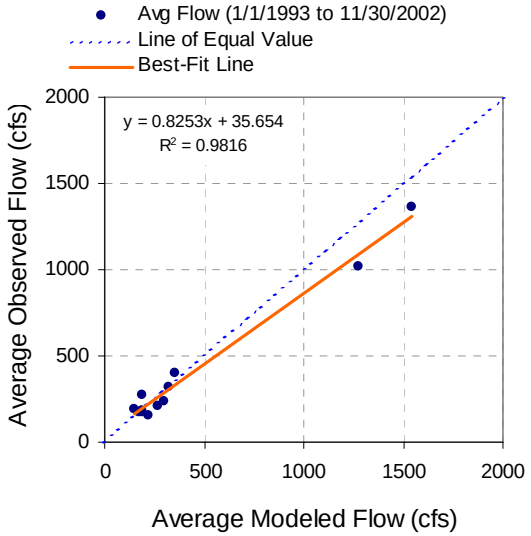
Tongue River at State Line near Decker, MT

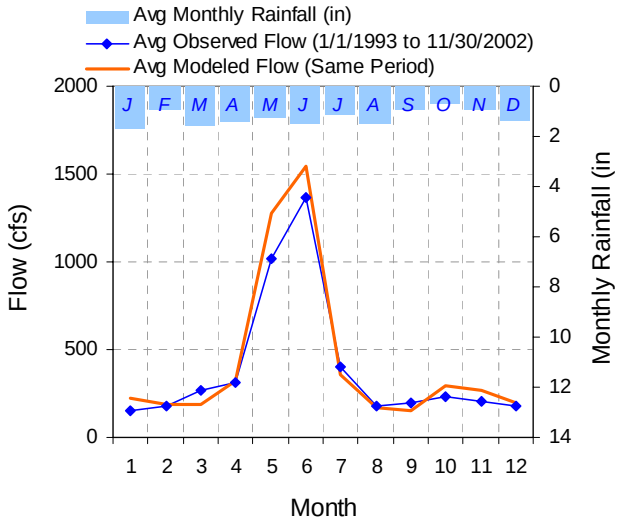


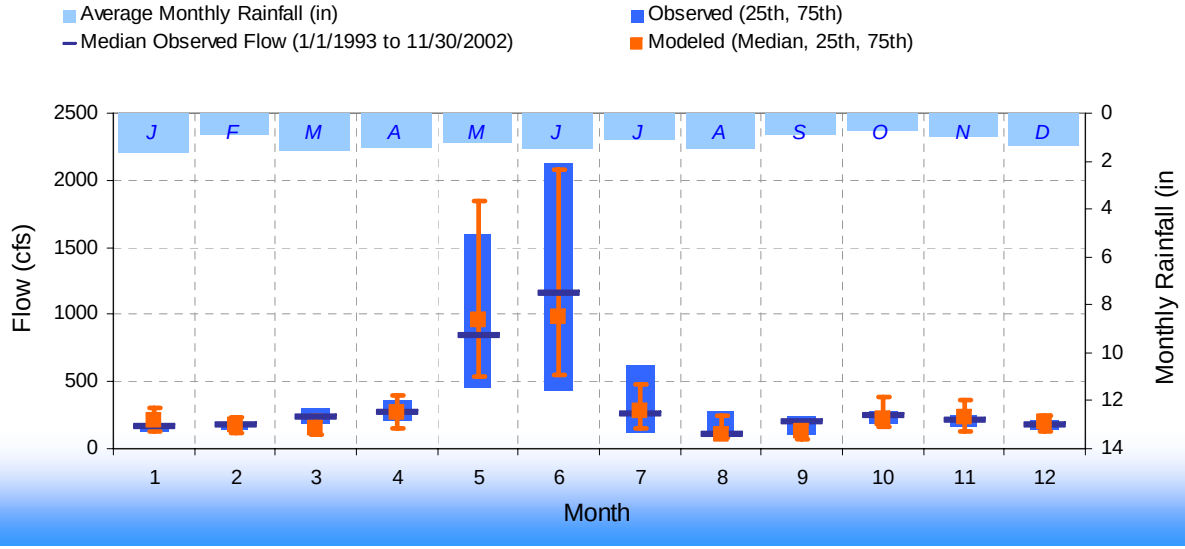
Tongue River at State Line near Decker, MT: Hydrologic Time Series



Tongue River at State Line near Decker, MT: Hydrologic Composite





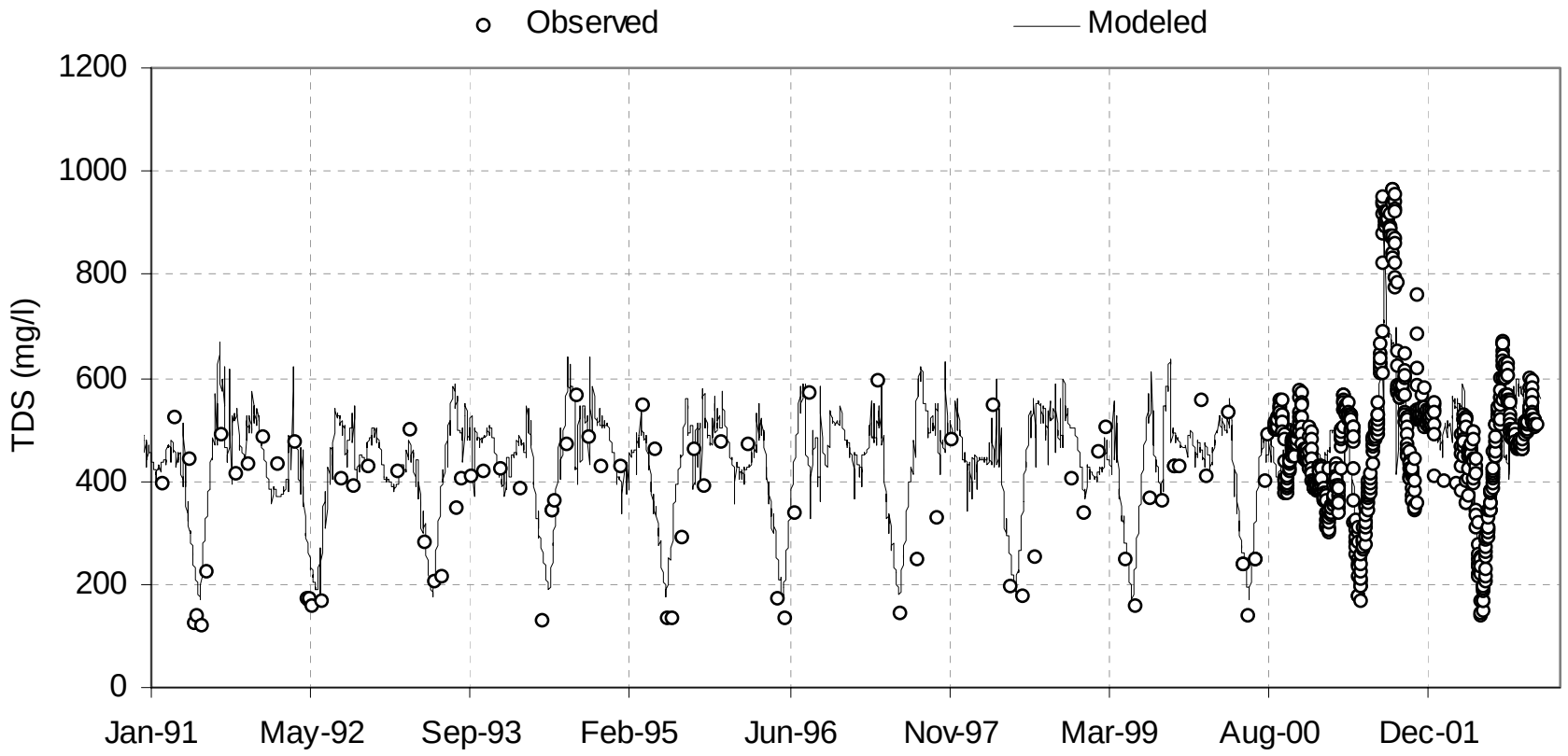


Tongue River at State Line near Decker, MT: Hydrologic Statistics

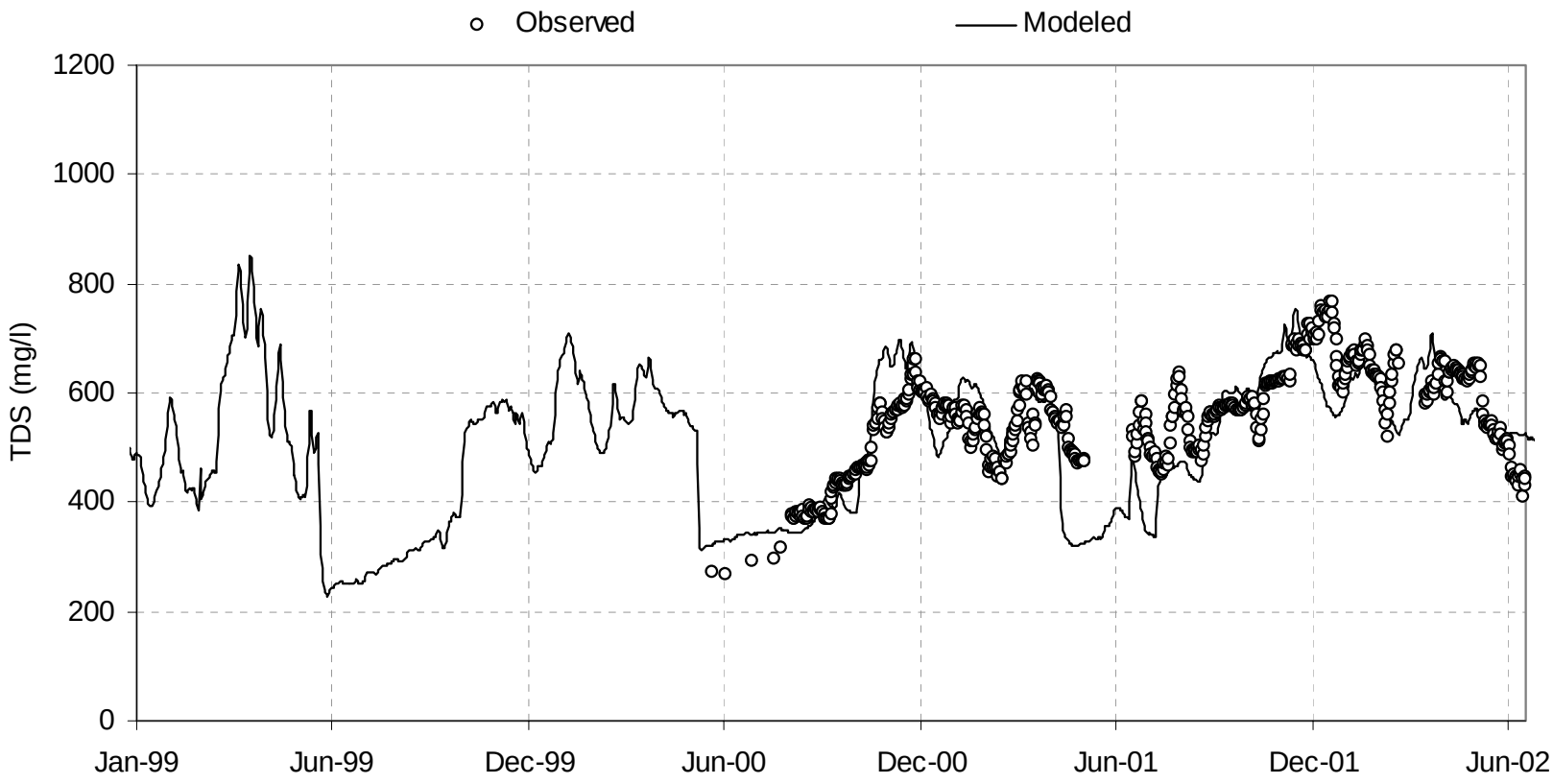
LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 3 9.91-Year Analysis Period: 1/1/1993 - 11/30/2002 Flow volumes are (inches/year) for upstream drainage area		USGS 06306300 Tongue River at State Line nr Decker MT Big Horn County, Montana Hydrologic Unit Code 10090101 Latitude 45°00'32", Longitude 106°50'08" NAD27 Drainage area 1,453.00 square miles	
Total Simulated In-stream Flow:	**178.23**	Total Observed In-stream Flow:	**161.79**
Total of simulated highest 10% flows:	**85.78**	Total of Observed highest 10% flows:	**73.18**
Total of Simulated lowest 50% flows:	**27.32**	Total of Observed Lowest 50% flows:	**29.85**
Simulated Summer Flow Volume (months 7-9):	**23.58**	Observed Summer Flow Volume (7-9):	**26.90**
Simulated Fall Flow Volume (months 10-12):	**25.77**	Observed Fall Flow Volume (10-12):	**20.99**
Simulated Winter Flow Volume (months 1-3):	**20.26**	Observed Winter Flow Volume (1-3):	**20.81**
Simulated Spring Flow Volume (months 4-6):	**108.62**	Observed Spring Flow Volume (4-6):	**93.09**
Total Simulated Storm Volume:	**32.41**	Total Observed Storm Volume:	**26.10**
Simulated Summer Storm Volume (7-9):	**3.79**	Observed Summer Storm Volume (7-9):	**3.92**

Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*		
Error in total volume:	9.22	10		
Error in 50% lowest flows:	-9.25	10		
Error in 10% highest flows:	14.70	15		
Seasonal volume error - Summer:	-14.09	30		
Seasonal volume error - Fall:	18.56	30		
Seasonal volume error - Winter:	-2.75	30		
Seasonal volume error - Spring:	14.30	30		
Error in storm volumes:	19.47	20		
Error in summer storm volumes:	-3.35	50		

Tongue River at State Line near Decker, MT: Water Quality



Tongue River Below Brandenberg Bridge, MT : Water Quality



Part 3 –Model Application

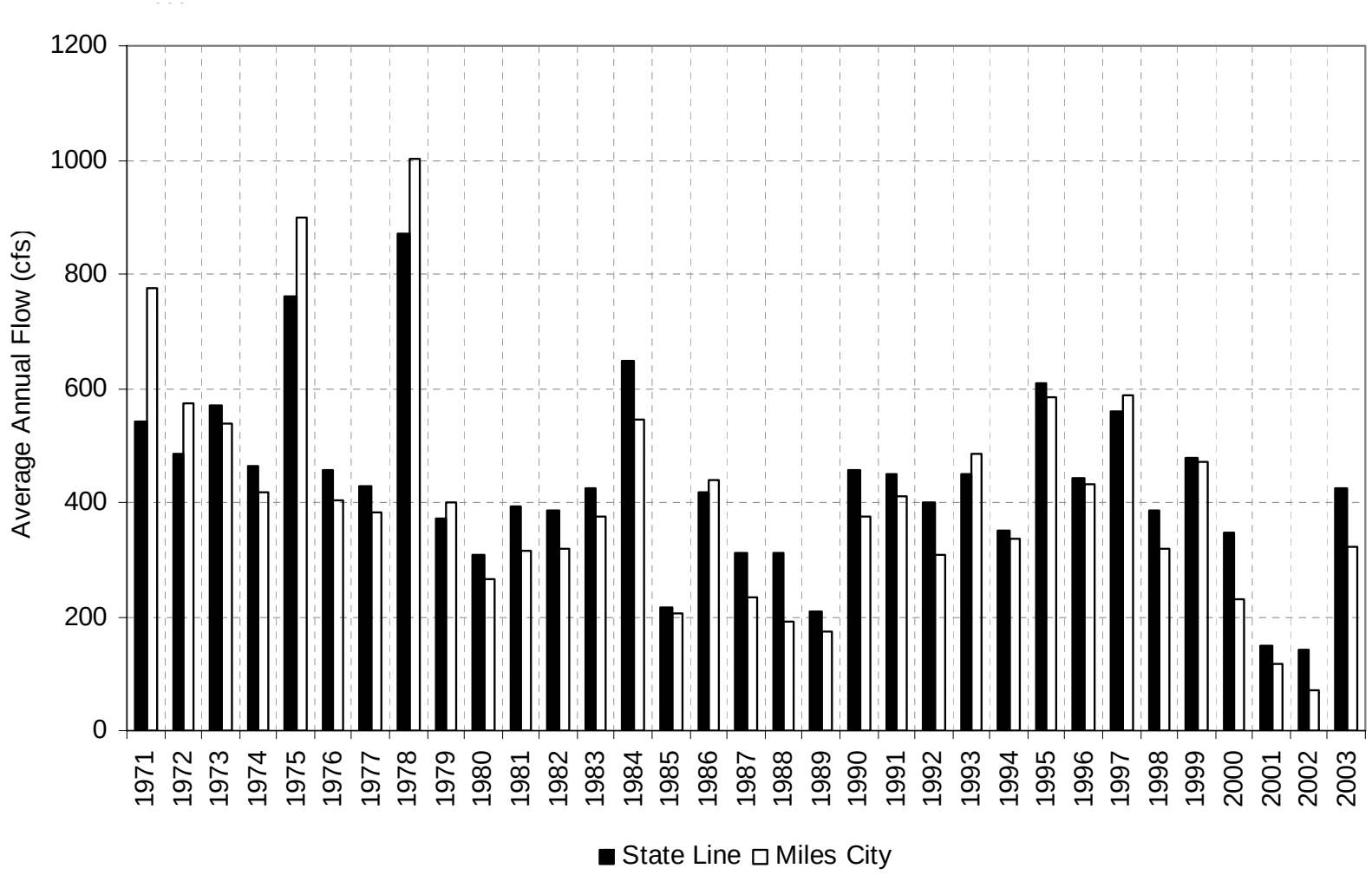
Modeling Scenarios

- Scenario 0: Existing conditions
  - Simulation of hydrology/water chemistry (EC/SAR) under current land use and point source discharge conditions
- Scenario 1: Baseline conditions
  - Simulation of hydrology/water chemistry (EC/SAR) under current land use conditions and assume that point sources discharge at their permit limits
- Scenario 2: Natural conditions
  - Same as “0” with hydrologic affects/ pollutants from man-caused sources omitted

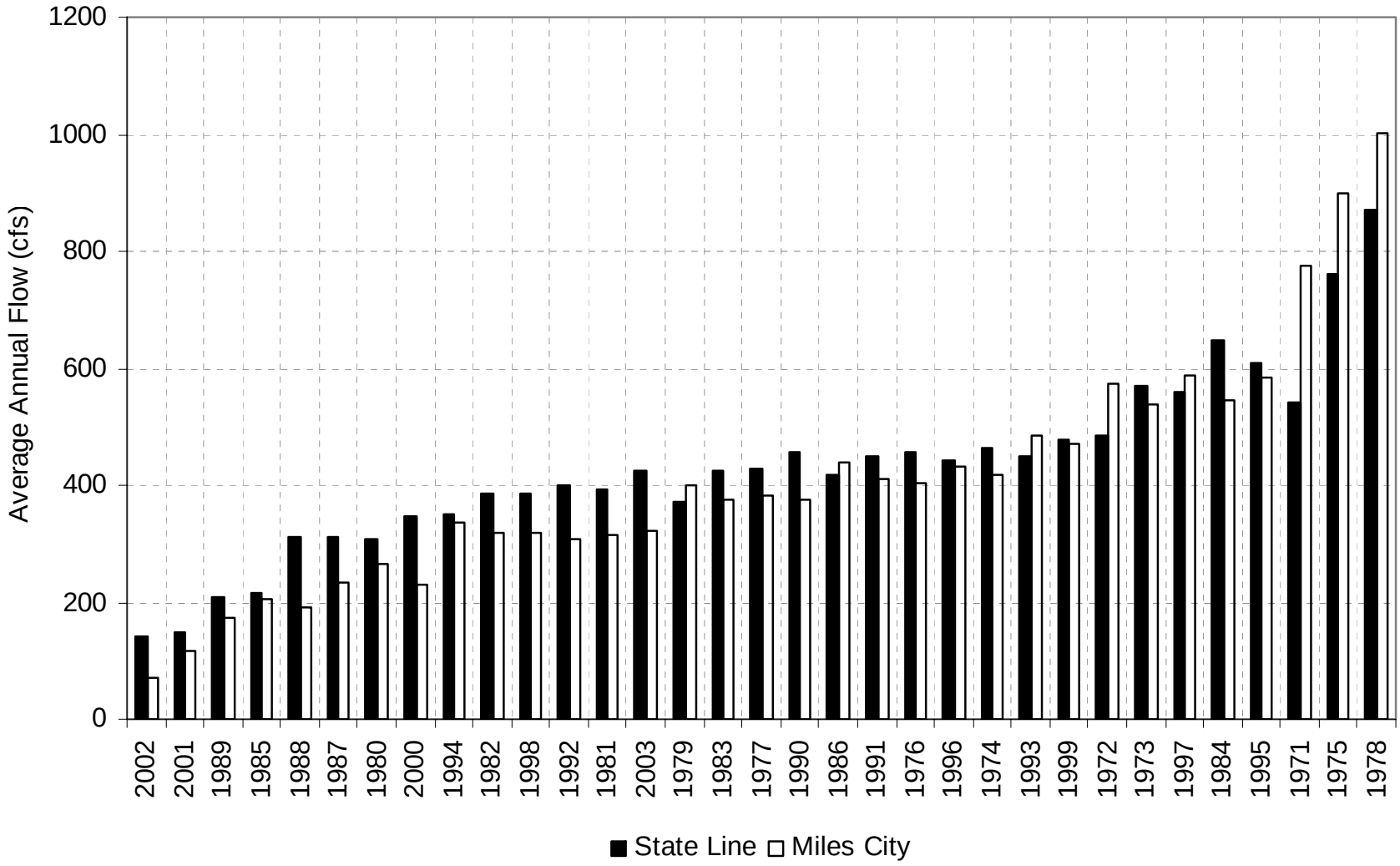
Critical Conditions

- Ability to run the model is restricted by appropriate input data (e.g., meteorology)
- Calibration performed for 1987 to 2002
- Period includes critical conditions as defined by the 30-year flow record
  - Normal years (1987, 1990, 1991, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000)
  - Wet years (1995, 1997)
  - Dry years (1988, 1989, 2001)
  - 7Q10 periods (August and September 2001 and June and August 2002)
- Scenarios run for hypothetical time period that includes 4 normal years, 1 wet year, and 1 dry year

Critical Conditions



Critical Conditions (cont.)



Part 4 – Updated Impairment Status

Salinity/TDS/SAR

- **How Did We Determine if Salinity/TDS/SAR is Impairing Beneficial Uses?**
  - Montana DEQ has instantaneous maximum and monthly average water quality criteria for salinity (as measured by electrical conductivity/ specific conductance) and SAR
  - Water chemistry data from various stations were evaluated to determine if concentrations are exceeding criteria
  - Watersheds were modeled to determine natural versus anthropogenic loads

Salinity/TDS/SAR (cont.)

- **What Data Did We Use To Determine If Salinity/TDS/SAR Are Impairing Beneficial Uses?**
  - In-stream water chemistry data (USGS, DEQ, EPA, Northern Cheyenne)
- **Complicating Issues**
  - Determining natural versus anthropogenic loads

Chlorides

- **How Did We Determine if Chlorides are Impairing Beneficial Uses?**
  - Montana has narrative standards applicable to chlorides. The prohibition against the creation of "conditions which produce undesirable aquatic life" is generally the most relevant.
  - Data were also compared to recommended literature values and standards from other western states
  - Water chemistry data from various stations were evaluated to determine if concentrations are exceeding indicators

Chlorides (cont.)

- **What Data Did We Use To Determine If Chlorides Are Impairing Beneficial Uses?**
  - In-stream water chemistry data (USGS, DEQ, EPA, Northern Cheyenne)

Sediment/Siltation/TSS

- **How Did We Determine if Sediment/Siltation is Impairing Beneficial Uses?**
  - Modeling
  - Riparian and Source Assessments
  - Aquatic life data were evaluated; however, it is difficult to link aquatic life impairment to sediment
    - For example, a negative result does not necessarily indicate a sediment impairment.

Sediment/Siltation/TSS

- **What Data Did We Use To Determine If Sediment/Siltation is Impairing Beneficial Uses?**
  - Macroinvertebrates, fish populations, and periphyton
  - Riparian habitat and source assessments
  - Modeled upland sediment loads
- **Complicating Issues**
  - Watersheds have highly erodible sediments and naturally high suspended sediment concentrations
  - No numeric criteria

Metals

- **How Did We Determine if Metals are Impairing Beneficial Uses?**
  - Montana DEQ has acute (maximum allowable) and chronic (4-day average) water quality criteria for total recoverable (TR) metals concentrations
  - Evaluated metals: arsenic, cadmium, copper, iron, lead, nickel, silver, selenium, zinc

Metals (cont.)

- **How Did We Determine if Metals are Impairing Beneficial Uses?**
  - Water chemistry data from various stations were evaluated to determine if concentrations are exceeding criteria
  - Dissolved metals concentrations were also evaluated where available
  - Aquatic life data were evaluated; however, it is difficult to link aquatic life impairment to metals
    - For example, a negative result does not necessarily indicate a metals impairment.

Metals (cont.)

- **What Data Did We Use To Determine If Metals Are Impairing Beneficial Uses?**
  - In-stream water chemistry data (USGS, DEQ, EPA, Northern Cheyenne)
  - Macroinvertebrates, fish populations, and periphyton
- **Complicating Issues**
  - Streams can have naturally high sediment concentrations that result in naturally high metal concentrations

Nutrients

- **How Did We Determine if Nutrients are Impairing Beneficial Uses?**
  - Montana has narrative standards applicable to nutrients
  - The prohibition against the creation of “conditions which produce undesirable aquatic life” is generally the most relevant.
  - Nutrient indicators were derived from previous Montana DEQ and EPA studies
  - Evaluated nutrients: nitrogen and phosphorus

Nutrients (cont.)

- **How Did We Determine if Nutrients are Impairing Beneficial Uses?**
  - Water chemistry data from various stations were evaluated to determine if concentrations are exceeding indicators
  - Organic enrichment indicators, such as benthic chlorophyll-*a* and dissolved oxygen concentrations, were also evaluated
  - Aquatic life data were evaluated;however, it is difficult to link aquatic life impairment to nutrients
    - For example, a negative result does not necessarily indicate a nutrient impairment.

Nutrients (cont.)

- **What Data Did We Use To Determine If Nutrients Are Impairing Beneficial Uses?**
  - In-stream water chemistry data (USGS, DEQ, EPA, Northern Cheyenne)
  - Macroinvertebrates, fish populations, and periphyton
  - Benthic and water column chlorophyll-*a* data
  - Modeling
- **Complicating Issues**
  - Streams can have naturally high sediment concentrations that can result in naturally high nutrient concentrations
  - No numeric criteria

Pathogens

- **How Did We Determine if Pathogens are Impairing Beneficial Uses?**
  - Montana DEQ has acute (maximum allowable) and chronic (geometric mean) water quality criteria for fecal coliforms
  - Compared fecal coliform data collected over a one month period, as well as long term data, to the criteria
  - Source assessment and modeling conducted to evaluate loads

Pathogens (cont.)

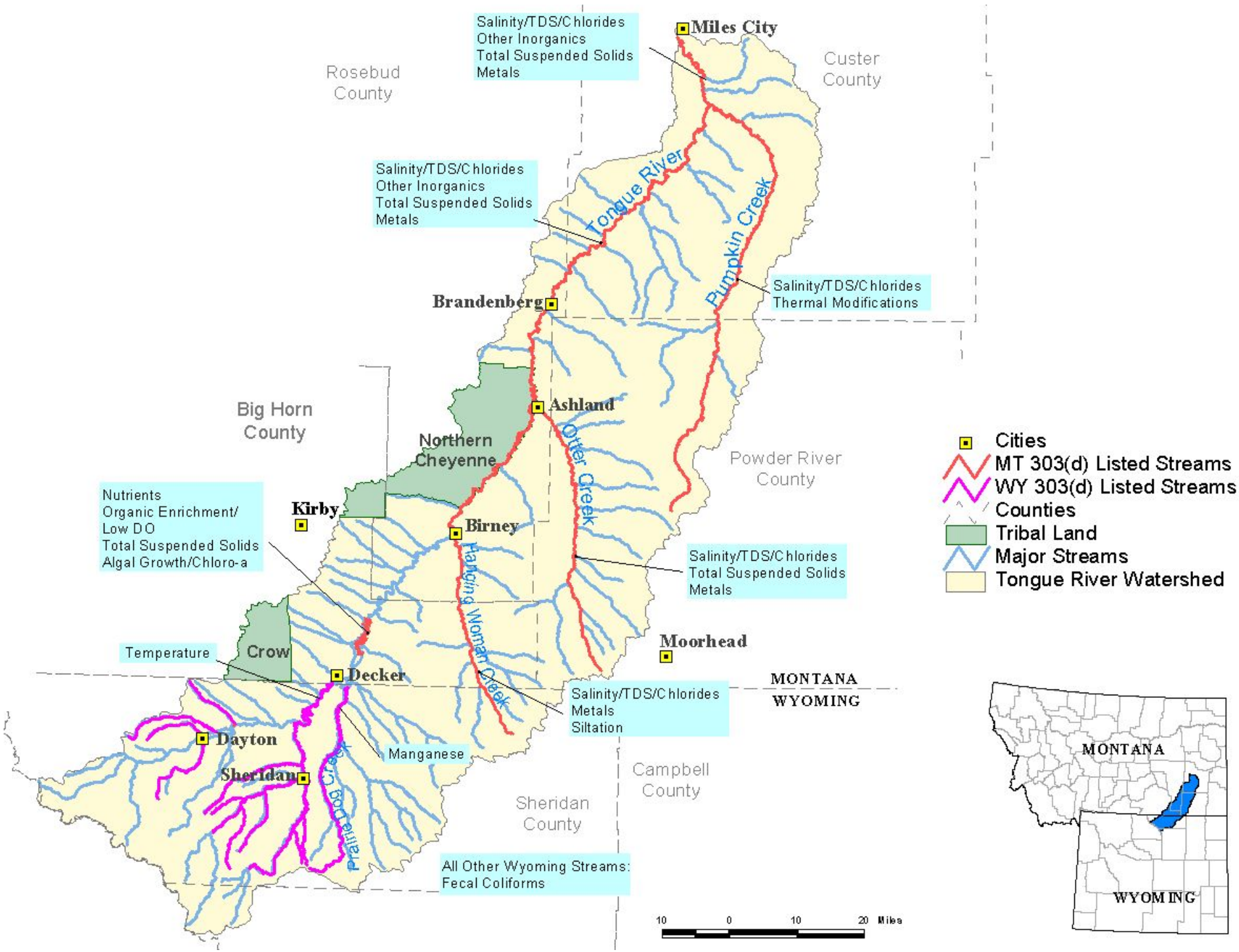
- **What Data Did We Use To Determine If Nutrients Are Impairing Beneficial Uses?**
  - In-stream coliform data (USGS, DEQ)
- **Complicating Issues**
  - Determining natural versus anthropogenic loads

Thermal Modifications

- **How Did We Determine if Thermal Modifications are Impairing Beneficial Uses?**
  - Montana DEQ has narrative and numeric standards that apply to thermal modifications
  - Temperature data for 2 different in-stream reaches and various references reaches were compared
  - Aquatic life data were evaluated; however, it is difficult to link aquatic life impairment to temperature
    - For example, a negative result does not necessarily indicate a temperature impairment.

Thermal Modifications (cont.)

- **What Data Did We Use To Determine If Thermal Modifications Are Impairing Beneficial Uses?**
  - In-stream temperature data (USGS, DEQ, EPA)
  - Macroinvertebrates, fish populations, and periphyton
  - Riparian assessments
- **Complicating Issues**
  - Pumpkin Creek (the only tributary listed for temperature impairment) is an intermittent, plains stream with standing pools of water which can have naturally high temperatures


Miles City
Salinity/TDS/Chlorides
Other Inorganics
Total Suspended Solids
Metals
Rosebud County
Custer County
Tongue River
Pumpkin Creek
Salinity/TDS/Chlorides
Other Inorganics
Total Suspended Solids
Metals
Salinity/TDS/Chlorides
Thermal Modifications
Brandenberg
Ashland
Big Horn County
Northern Cheyenne
Otter Creek
Powder River County
Nutrients
Organic Enrichment/
Low DO
Total Suspended Solids
Algal Growth/Chloro-a
Kirby
Birney
Hanging Woman Creek
Salinity/TDS/Chlorides
Total Suspended Solids
Metals
Moorhead
Crow
Temperature
Decker
MONTANA
WYOMING
Salinity/TDS/Chlorides
Metals
Siltation
Dayton
Manganese
Sheridan
Prairie Dog Creek
Campbell County
Sheridan County
All Other Wyoming Streams:
Fecal Coliforms
10 0 10 20 Miles
Cities
MT 303(d) Listed Streams
WY 303(d) Listed Streams
Counties
Tribal Land
Major Streams
Tongue River Watershed
MONTANA
WYOMING

Tongue River Watershed

Montana 1996 303(d) List

Segment	Size (mi)	Impaired Uses	Probable Cause
Tongue River (WY border to Tongue River Reservoir) (Tongue River Above Reservoir)	4	Agriculture Aquatic life Coldwater fishery	Flow alteration
Tongue River Reservoir	3,500 acres	Aquatic life Coldwater fishery Swimmable	Nutrients Organic enrichment/ dissolved oxygen Suspended solids
Tongue River (TRR Dam to the confluence with Hanging Women Creek) (Upper Tongue River)	31	Aquatic life Coldwater fishery	Flow alteration
Tongue River (Hanging Women Creek to diversion dam) (Middle Tongue River)	117.6	Agriculture Aquatic life Warmwater fishery	Flow alteration Metals Other inorganics Salinity/TDS/chlorides Suspended solids
Tongue River (diversion dam to mouth) (Lower Tongue River)	20.4	Agriculture Aquatic life Warmwater fishery	Flow alteration Metals Other inorganics Salinity/TDS/chlorides Suspended solids
Hanging Woman Creek	30	Agriculture Aquatic life Warmwater fishery	Flow alteration Metals Salinity/TDS/chlorides
Otter Creek	53	Agriculture Aquatic life Warmwater fishery	Metals Other habitat alterations Salinity/TDS/chlorides Suspended solids
Pumpkin Creek	87	Agriculture Aquatic life Warmwater fishery	Flow alteration Salinity/TDS/chlorides Thermal modifications

Tongue River Watershed

Montana 2002/2004 303(d) List

Segment	Size	Use	Use Status[a]	Probable Cause
Tongue River Reservoir	3,500 acres	B-2	Aquatic life (partial) Cold water fish (not assessed) Drinking water (not assessed) Swimming/recreation (partial) Agricultural (full) Industrial (full)	Algal growth/ chlorophyll-*a*
Tongue River from the diversion dam to the mouth	20.4 mi	B-3	Aquatic life (partial) Warm water fish (partial) Drinking Water (not assessed) Swimming/recreation (partial) Agricultural (full) Industrial (full)	Flow alteration
Hanging Woman Creek from Stroud Creek to the mouth	18.5 mi	C-3	Aquatic life (partial) Warm water fish (partial) Swimming/recreation (not assessed) Drinking water (not assessed) Agricultural (not assessed) Industrial (not assessed)	Siltation

Tongue River (Upstream of Reservoir) – Summary

- Salinity/TDS – Not Impaired
- Chlorides – Not Impaired
- SAR – Not Impaired

Tongue River (TRR Dam to T&Y Canal) – Summary

- Salinity/TDS – Not Impaired
- Chlorides – Not Impaired
- SAR – Not Impaired
- Metals – Not Impaired
- Suspended Solids – To Be Assessed

Tongue River (T&Y Canal to Mouth) – Summary

- Salinity/TDS – Impaired
- Chlorides – Not Impaired
- SAR – Not Impaired
- Metals – Not Impaired
- Suspended Solids – To Be Assessed

Tongue River Reservoir – Summary

- Salinity/TDS – Not Impaired
- Chlorides – Not Impaired
- SAR – Not Impaired
- Nutrients – To Be Assessed
- Organic Enrichment/Low DO – To Be Assessed
- Suspended Solids – To Be Assessed

Hanging Woman Creek– Summary

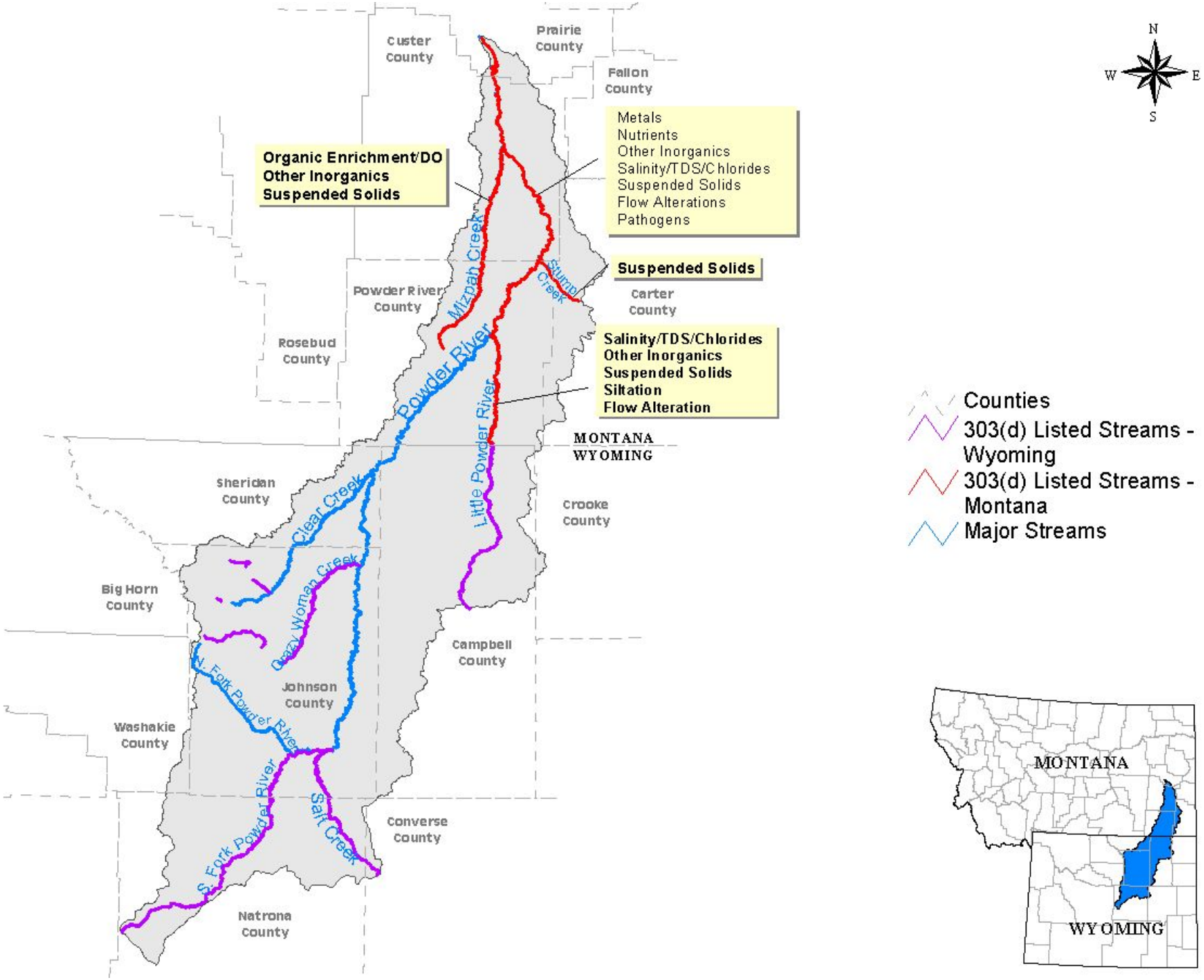
- Salinity/TDS – Naturally Exceeds Criteria
- Chlorides – Not Impaired
- SAR – Naturally Exceeds Criteria
- Metals – Not Impaired
- Siltation/Suspended Solids – To Be Assessed

Otter Creek – Summary

- Salinity/TDS – Naturally Exceeds Criteria
- Chlorides – Not Impaired
- SAR – Naturally Exceeds Criteria
- Metals – Not Impaired
- Suspended Solids – To Be Assessed

Pumpkin Creek – Summary

- Salinity/TDS – Naturally Exceeds Criteria
- Chlorides – Not Impaired
- SAR – Naturally Exceeds Criteria
- Thermal Modifications – To Be Assessed


Custer County
Prairie County
Fallon County
Carter County
Powder River County
Rosebud County
Sheridan County
Big Horn County
Washakie County
Johnson County
Campbell County
Crooke County
Converse County
Natrona County
MONTANA
WYOMING
Organic Enrichment/DO
Other Inorganics
Suspended Solids
Metals
Nutrients
Other Inorganics
Salinity/TDS/Chlorides
Suspended Solids
Flow Alterations
Pathogens
Suspended Solids
Salinity/TDS/Chlorides
Other Inorganics
Suspended Solids
Siltation
Flow Alteration
Mizpah Creek
Stump Creek
Powder River
Little Powder River
Clear Creek
Crazy Woman Creek
N. Fork Powder River
S. Fork Powder River
Salt Creek
N
W
E
S
Counties
303(d) Listed Streams - Wyoming
303(d) Listed Streams - Montana
Major Streams
MONTANA
WYOMING

Powder River Watershed

Montana 1996 303(d) List

Segment Name	USGS HUC	Estimated Size (mi)	Probable Impaired Uses	Probable Causes
Lower Powder River	10090209	134	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Metals Nutrients Other Inorganics Salinity/TDS/Chlorides Suspended Solids Flow Alteration Pathogens
Little Powder River	10090208	51	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Salinity/TDS/Chlorides Other Inorganics Suspended Solids Siltation Flow Alteration
Stump Creek	10090209	4	Aquatic Life Support	Suspended Solids
Mizpah Creek	10090210	80	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Organic Enrichment/DO Other Inorganics Suspended Solids

Powder River Watershed

- Montana 2002/2004 303(d) List
  - Powder River – Insufficient Credible Data
  - Stump Creek – Insufficient Credible Data
  - Little Powder River – Insufficient Credible Data
  - Mizpah Creek – Insufficient Credible Data

Powder River – Summary

- Salinity/TDS – To Be Assessed
- Chlorides – To Be Assessed
- SAR – To Be Assessed
- Metals – Naturally Exceeds Criteria
- Suspended Solids – Not Impaired
- Nutrients – Naturally Exceeds Indicators
- Sulfate – To Be Assessed
- Pathogens – To Be Assessed

Powder River – Suspended Solids

- NRCS Riparian Assessment
  - Conclusion: “The Powder River riparian corridor was found to be currently functioning to the level of a natural, braided system”
- Literature and historic references documenting sediment loads and natural channel erosion
- “Good” rating for fish IBI
- Very low percent fines and “good” rating for bed stability metrics
- Conclusion: Not Impaired Because of Sediment

Little Powder River – Summary

- Salinity/TDS – To Be Assessed
- SAR – To Be Assessed
- Chlorides – To Be Assessed
- Sulfate – To Be Assessed
- Suspended Solids/Siltation – Not Impaired

Little Powder River – Suspended Solids/Siltation

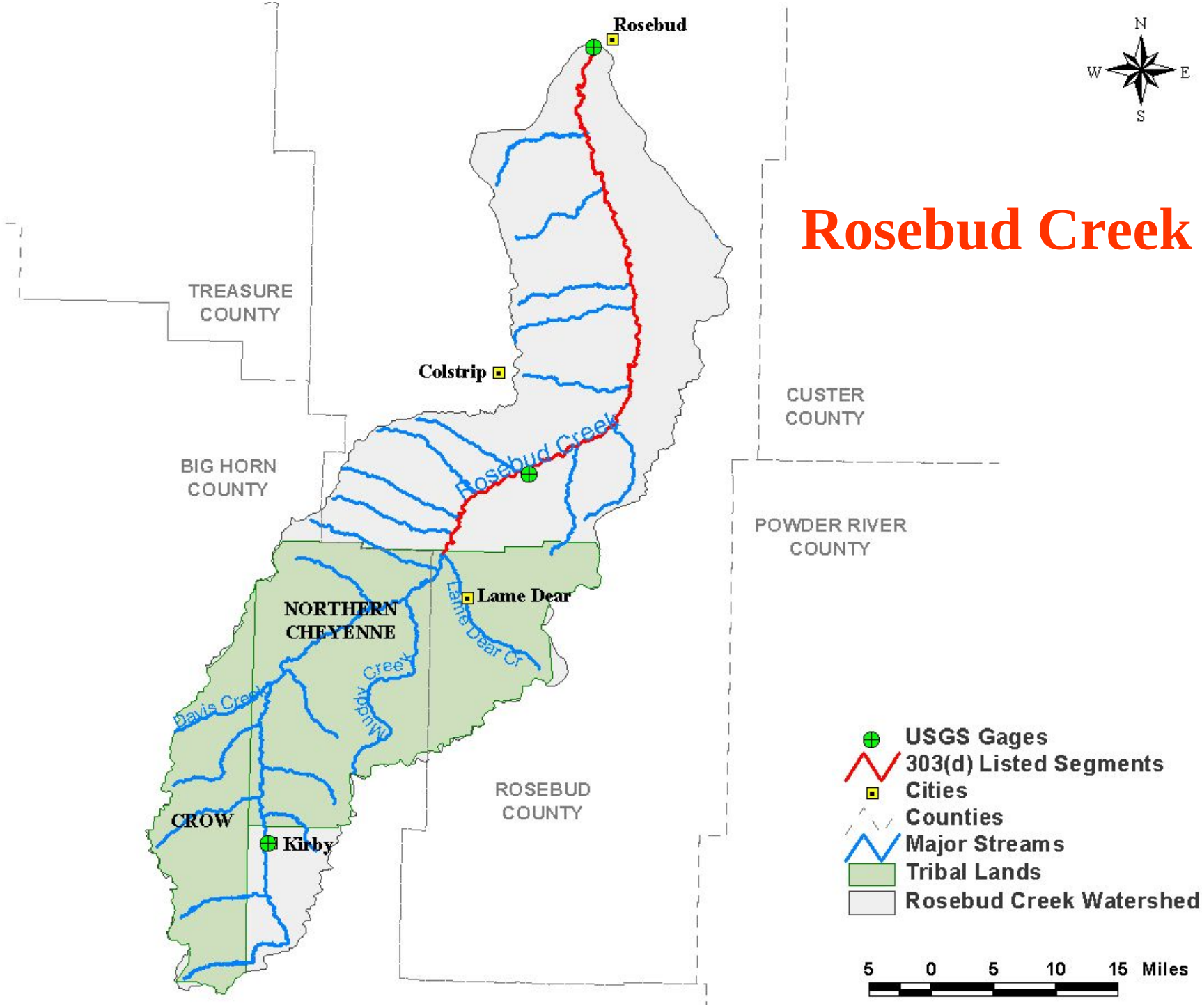
- 2000/2001 Biology Sampling (2 years, 3 sites)
  - All macro communities rated “fully supporting”
  - 2 out of 3 sites with fully supported fish communities (1 rated “fair”)
  - Relatively low percent fines and bed stability metrics found at each site
- NRCS Riparian Assessment
  - 11 out of 11 sites rated “Sustainable” (good)
  - “Channel has evidence of old downcutting that has begun stabilizing, vegetation is beginning to establish” and “there is minimal amount of active lateral bank erosion occurring,”
  - “The majority of the Little Powder River system was very stable with adequate vegetation and floodplain access to currently sustain the stream corridor resource values.”
- Conclusion: Not Impaired Because of Sediment/Siltation

Stump Creek – Summary

- Suspended Solids – Not Impaired

Mizpah Creek – Summary

- Salinity/TDS – To Be Assessed
- Chlorides – To Be Assessed
- SAR – To Be Assessed
- Sulfate – Not Impaired
- Organic Enrichment/DO – To Be Assessed
- Suspended Solids – To Be Assessed



Rosebud Creek

Rosebud Creek

1996 303(d) List

Segment Name	Estimated Size (mi)	Probable Impaired Uses	Probable Cause
Rosebud Creek (Lower and Middle Rosebud Creek)	114	Aquatic life Warmwater fishery	Flow Alteration Suspended Solids Salinity/TDS/Chlorides Other Inorganics Nutrients Metals

2002/2004 303(d) List

Segment Name	Size (mi)	Use Status[a]	Probable Cause
Rosebud Creek - from the mouth 3.8 miles upstream to an irrigation dam (Lower Rosebud Creek)	3.8	Agriculture (not assessed) Aquatic life (partial) Fishery (partial) Industrial (not assessed) Recreation (not assessed)	Bank erosion Other habitat alterations
Rosebud Creek - from the Northern Cheyenne Reservation boundary to the irrigation dam (Middle Rosebud Creek)	105.8	Agriculture (not assessed) Aquatic life (not assessed) Fishery (partial) Industrial (not assessed) Recreation (not assessed)	Other Nutrients

Rosebud Creek – Summary

- Salinity/TDS – Naturally Exceeds Criteria
- SAR – To Be Assessed
- Chlorides – Not Impaired
- Metals – Not Impaired
- Nutrients – Impaired
- Sulfate – To Be Assessed
- Suspended Solids – To Be Assessed

Rosebud Creek – Metals

- Iron criterion was exceeded at multiple sites, but is a natural condition
- One high flow sampling event in August 2001 resulted in almost ALL metals exceeding chronic criteria. However, evidence suggests that this is most likely because of VERY high suspended sediment concentrations at the time of sampling (21,600 mg/L TSS)
- Mostly very low metals concentrations at 3 sites in 2003
- Macroinvertebrate IBI Score – Good
- Fish IBI Score – Good/Fair
- Periphyton IBI Score – Good
- Conclusion: Not Impaired Because of Metals

Rosebud Creek – Nutrients

- Benthic chlorophyll-*a* exceeds indicator value at middle and upper sites
- Nuisance algae observed during site visits
- Several water chemistry indicator values exceeded at middle and upper sites
- Organic loading indicators noted in several macroinvertebrate and periphyton assessments

Rosebud Creek – Nutrients/ Further Investigations

- Stream is intermittent
  - Lower Site: 22 out of 27 years with periods of flow less than 1 cfs;
  - Middle site: 15 out of 27 years with periods of no flow
  - Therefore, naturally has standing pool system typical of SE Montana ephemeral streams, high algae and nutrients can be expected
- Macro/Periphyton IBI rates good
- Macro data during high flow years rates better than macro data taken during low flow years

Part 5 – Predictive Simulation Results

Tongue River – Impairment Status Applications

- Model applied to assist in making impairment status determinations
- Modeled existing condition (0), baseline condition (1), and natural condition (2)
- Following slides summarize results
  - Tongue River Mainstem
  - Tongue River Tributaries

Tongue River at Stateline

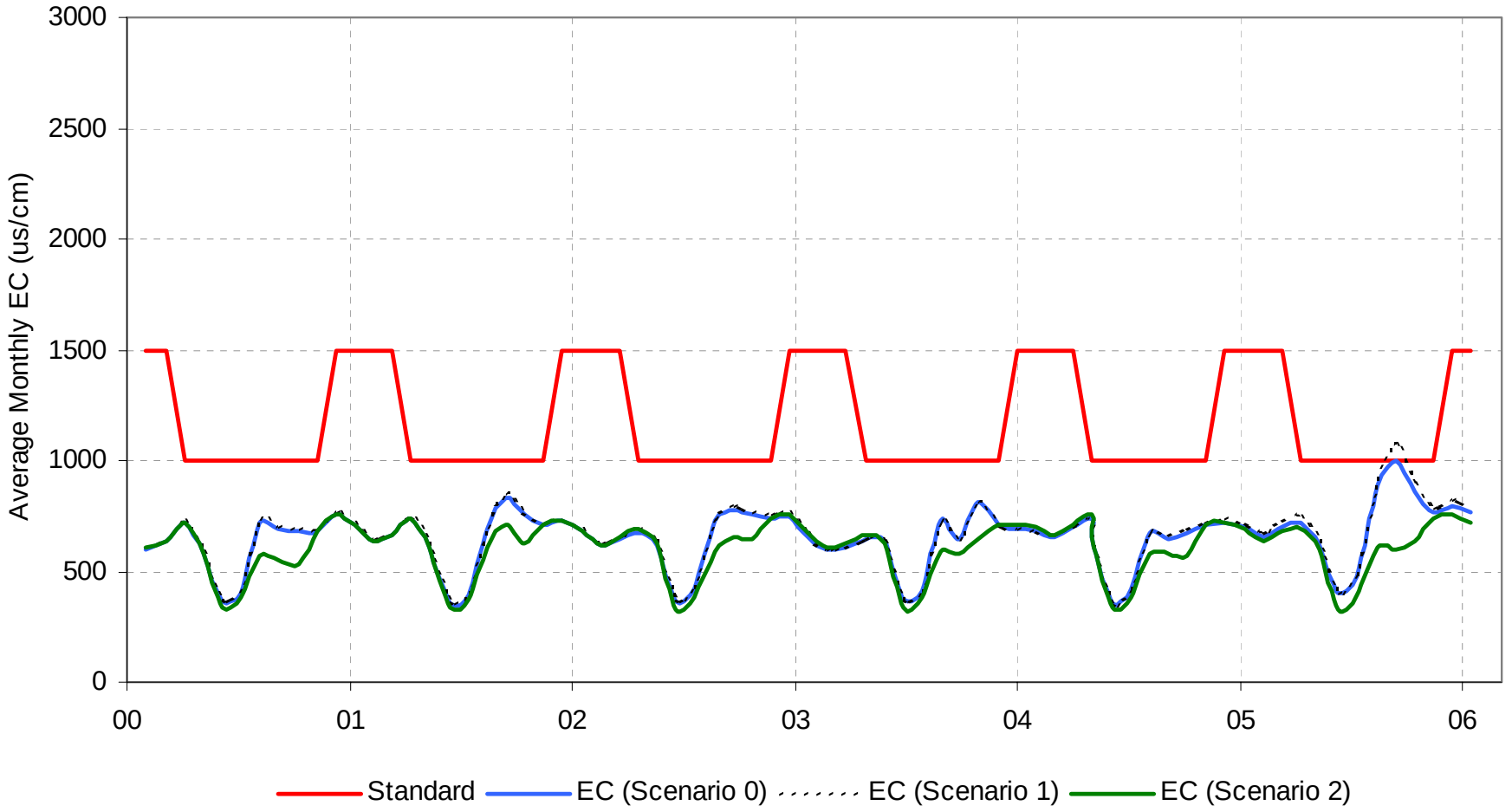
Existing Condition Versus Natural

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	0%	0%	2%	0%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	0%	0%	0%	0%

		Percentage Exceeding			
SAR	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 3.0	0%	0%	0	0%
Mar. 2 to Oct. 31 Instantaneous	< 4.5	0%	0%	0	0%
Nov. 1 to Mar. 1 Monthly Average	< 5.0	0%	0%	0	0%
Nov. 1 to Mar. 1 Instantaneous	< 7.5	0%	0%	0	0%

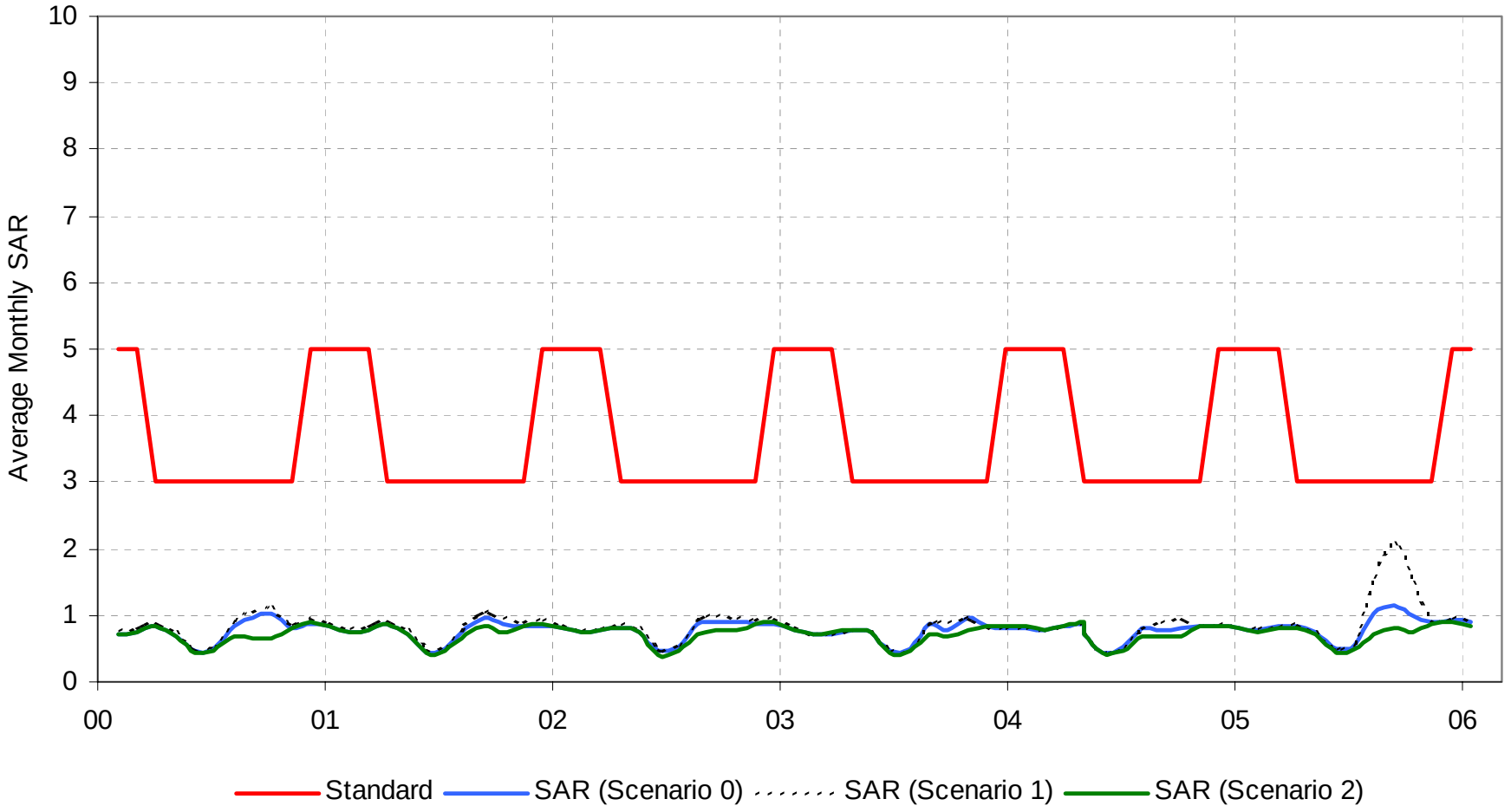
Tongue River at Stateline

Existing Condition Versus Natural



Tongue River at Stateline

Existing Condition Versus Natural



Tongue River at Northern Cheyenne (Southern Boundary)

Existing Condition Versus Natural

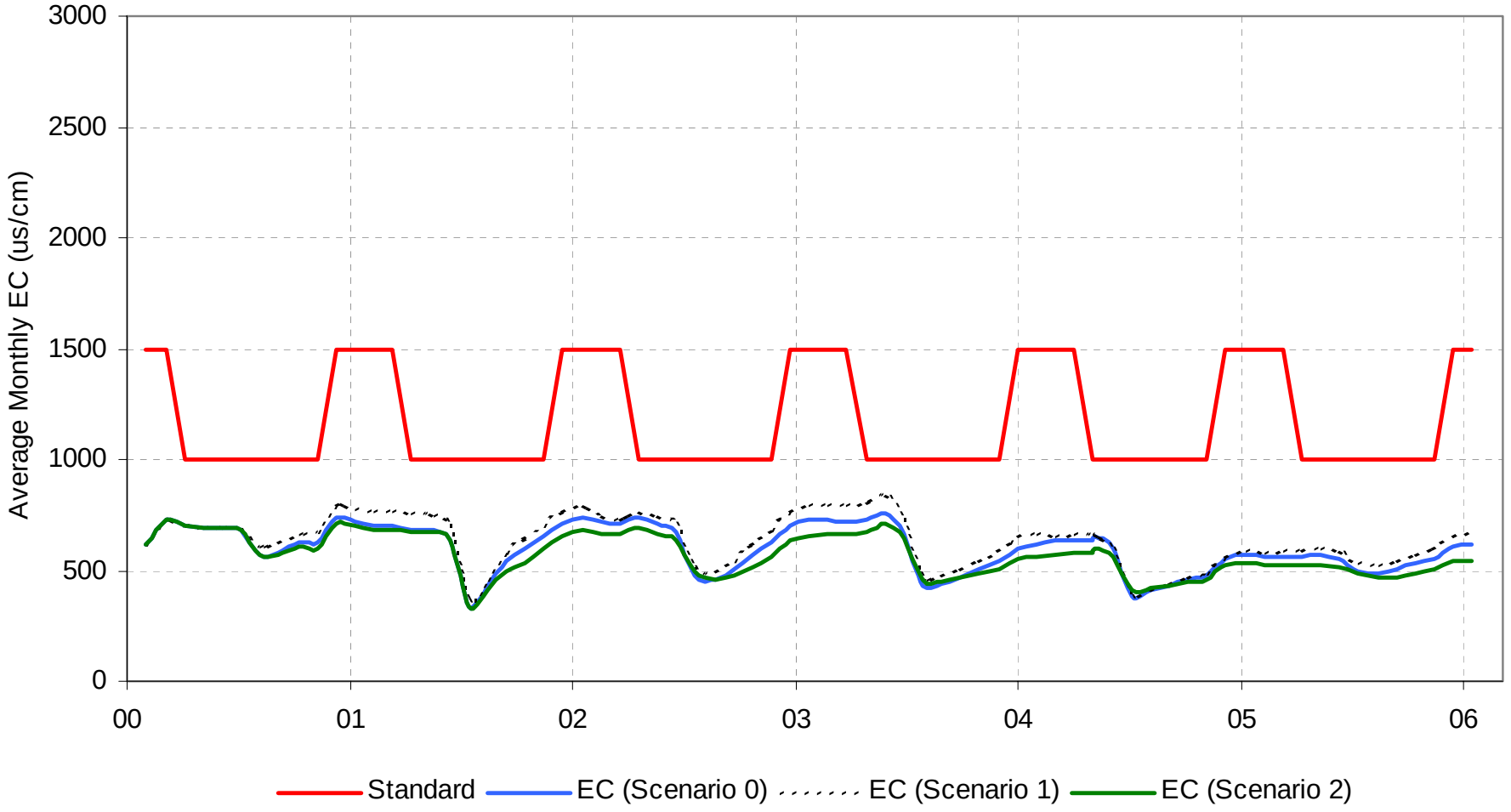
		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	0%	0%	0%	0%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	0%	0%	0%	0%

		Percentage Exceeding			
SAR	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 3.0	0%	0%	0%	0%
Mar. 2 to Oct. 31 Instantaneous	< 4.5	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 5.0	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 7.5	0%	0%	0%	0%

Northern Cheyenne Southern Border Proposed Standards
Growing Season Avg EC = 1,000 ; Max EC = 2,000
Growing Season Max SAR = 2.0

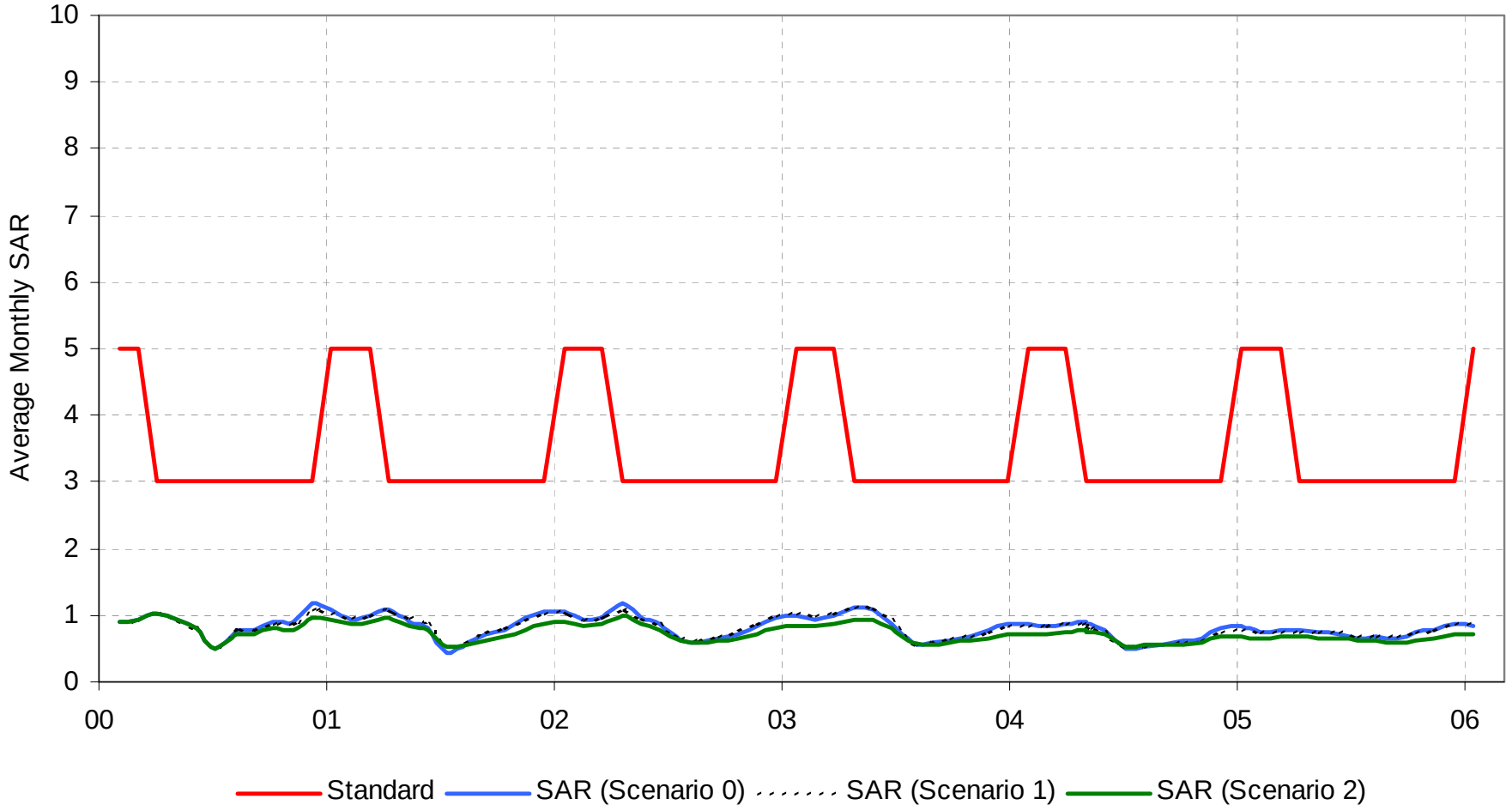
Tongue River at Northern Cheyenne (Southern Boundary)

Existing Condition Versus Natural



Tongue River at Northern Cheyenne (Southern Boundary)

Existing Condition Versus Natural



Tongue River at Brandenberg

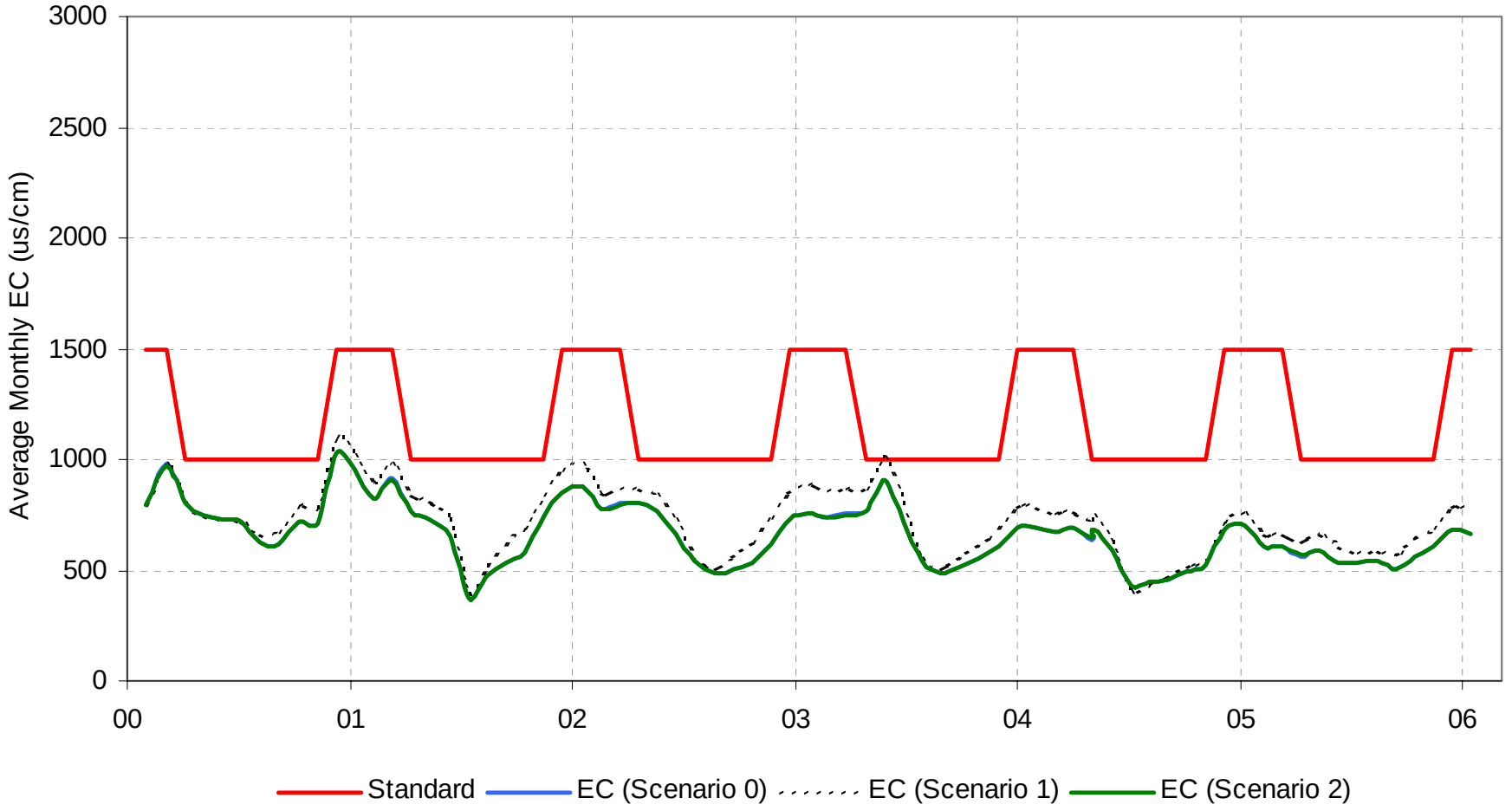
Existing Condition Versus Natural

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	0%	0%	2%	0%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	0%	0%	0%	0%

		Percentage Exceeding			
SAR	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 3.0	0%	0%	0	0%
Mar. 2 to Oct. 31 Instantaneous	< 4.5	0%	0%	0	0%
Nov. 1 to Mar. 1 Monthly Average	< 5.0	0%	0%	0	0%
Nov. 1 to Mar. 1 Instantaneous	< 7.5	0%	0%	0	0%

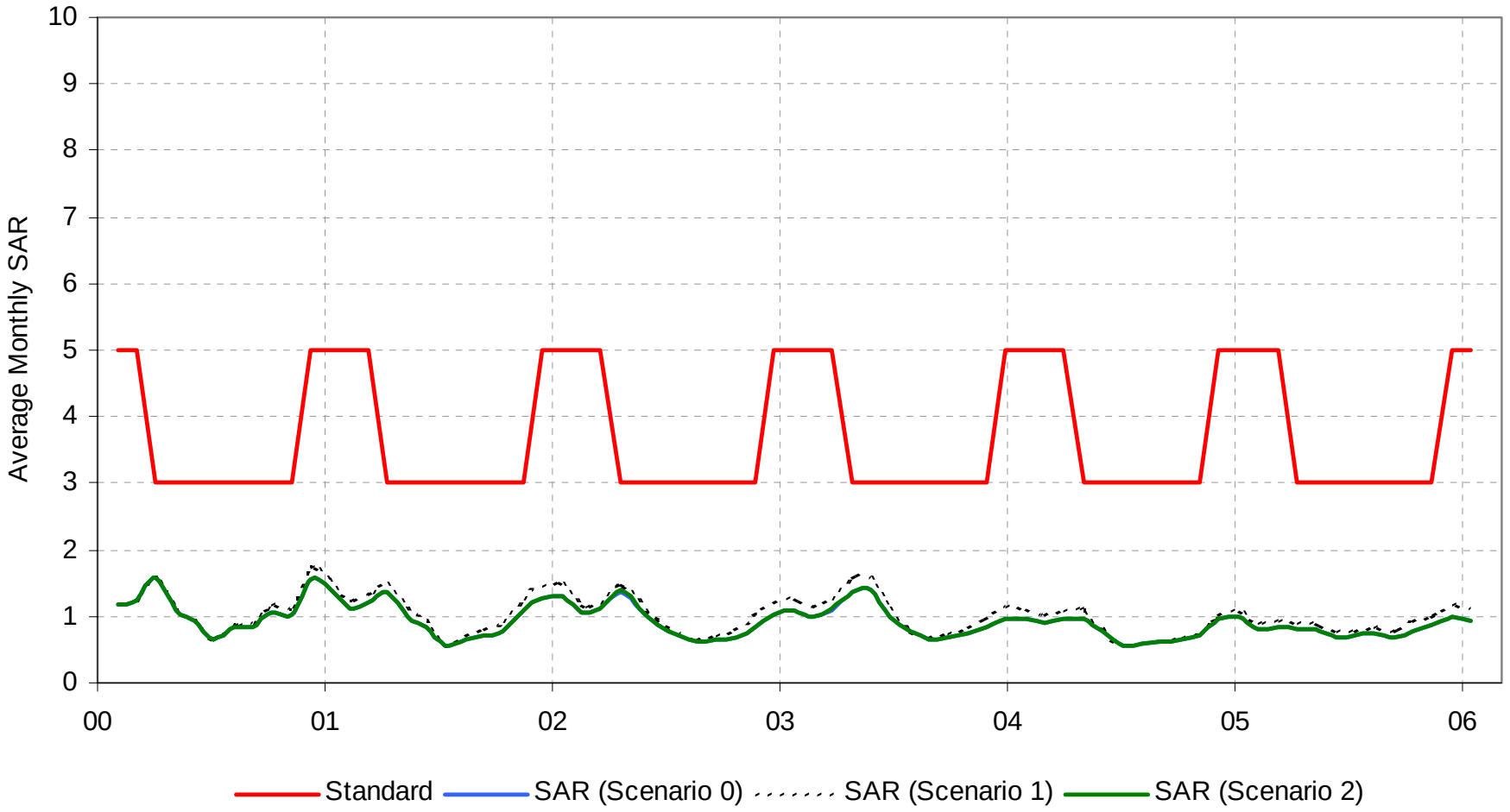
Tongue River at Brandenberg

Existing Condition Versus Natural



Tongue River at Brandenberg

Existing Condition Versus Natural



Tongue River Above T&Y Canal

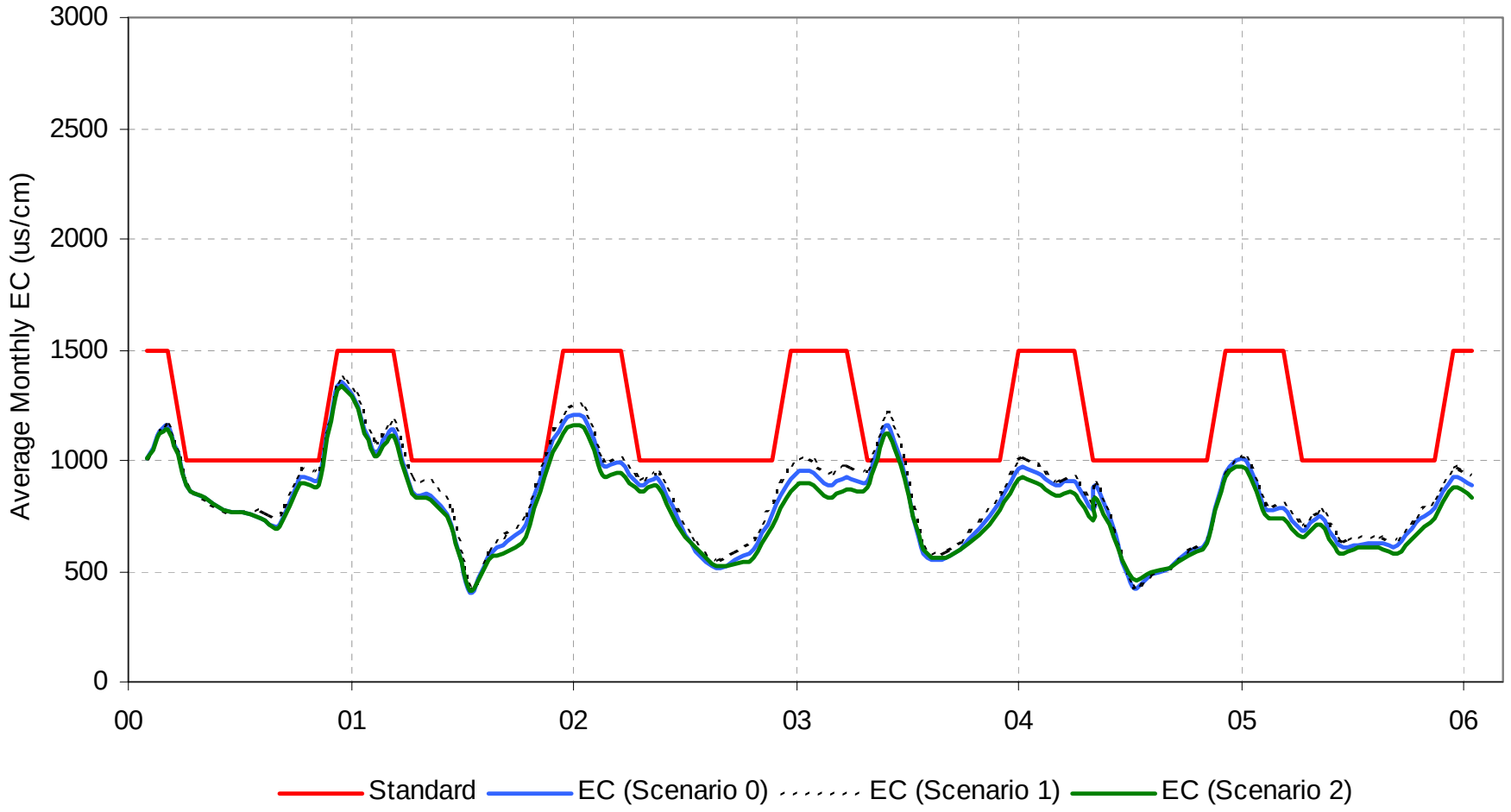
Existing Condition Versus Natural

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	0%	2%	4%	2%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	0%	0%	0%	0%

		Percentage Exceeding			
SAR	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 3.0	0%	0%	0%	0%
Mar. 2 to Oct. 31 Instantaneous	< 4.5	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 5.0	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 7.5	0%	0%	0%	0%

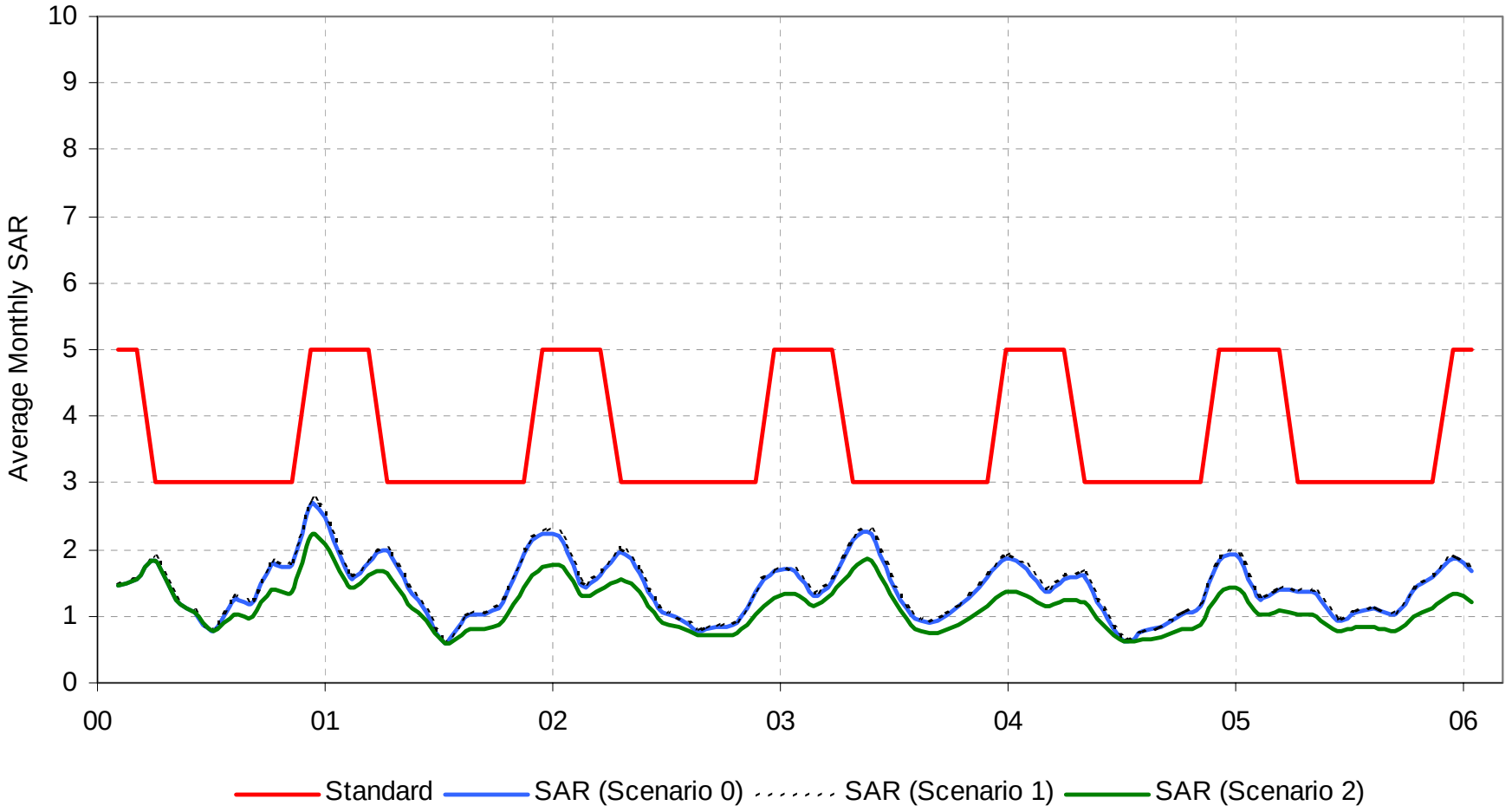
Tongue River Above T&Y Canal

Existing Condition Versus Natural



Tongue River Above T&Y Canal

Existing Condition Versus Natural



Tongue River at Miles City

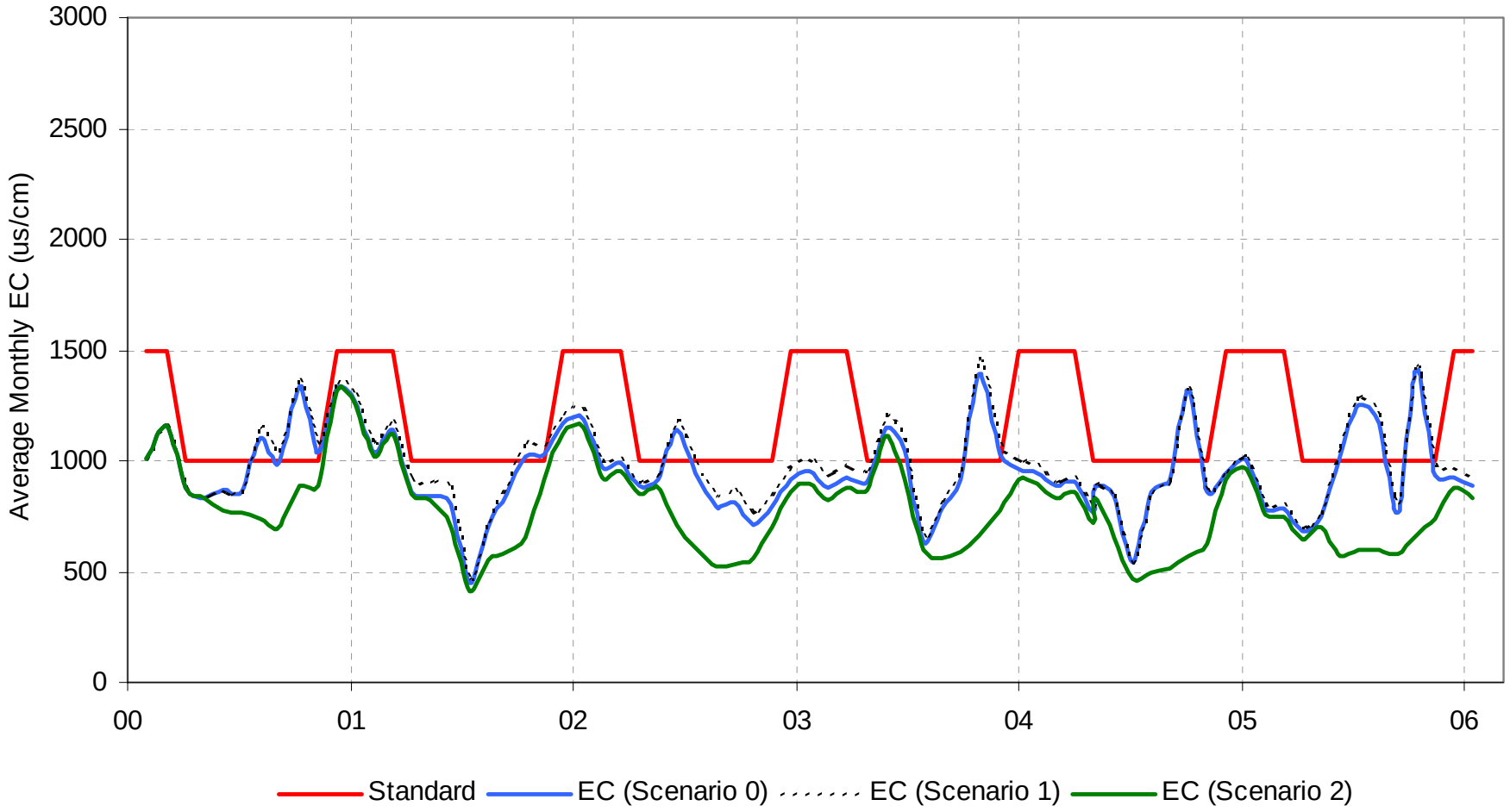
Existing Condition Versus Natural

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	24%	31%	33%	2%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	0%	6%	8%	0%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	0%	0%	0%	0%

		Percentage Exceeding			
SAR	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 3.0	0%	0%	0%	0%
Mar. 2 to Oct. 31 Instantaneous	< 4.5	0%	0%	0%	0%
Nov. 1 to Mar. 1 Monthly Average	< 5.0	0%	0%	0%	0%
Nov. 1 to Mar. 1 Instantaneous	< 7.5	0%	0%	0%	0%

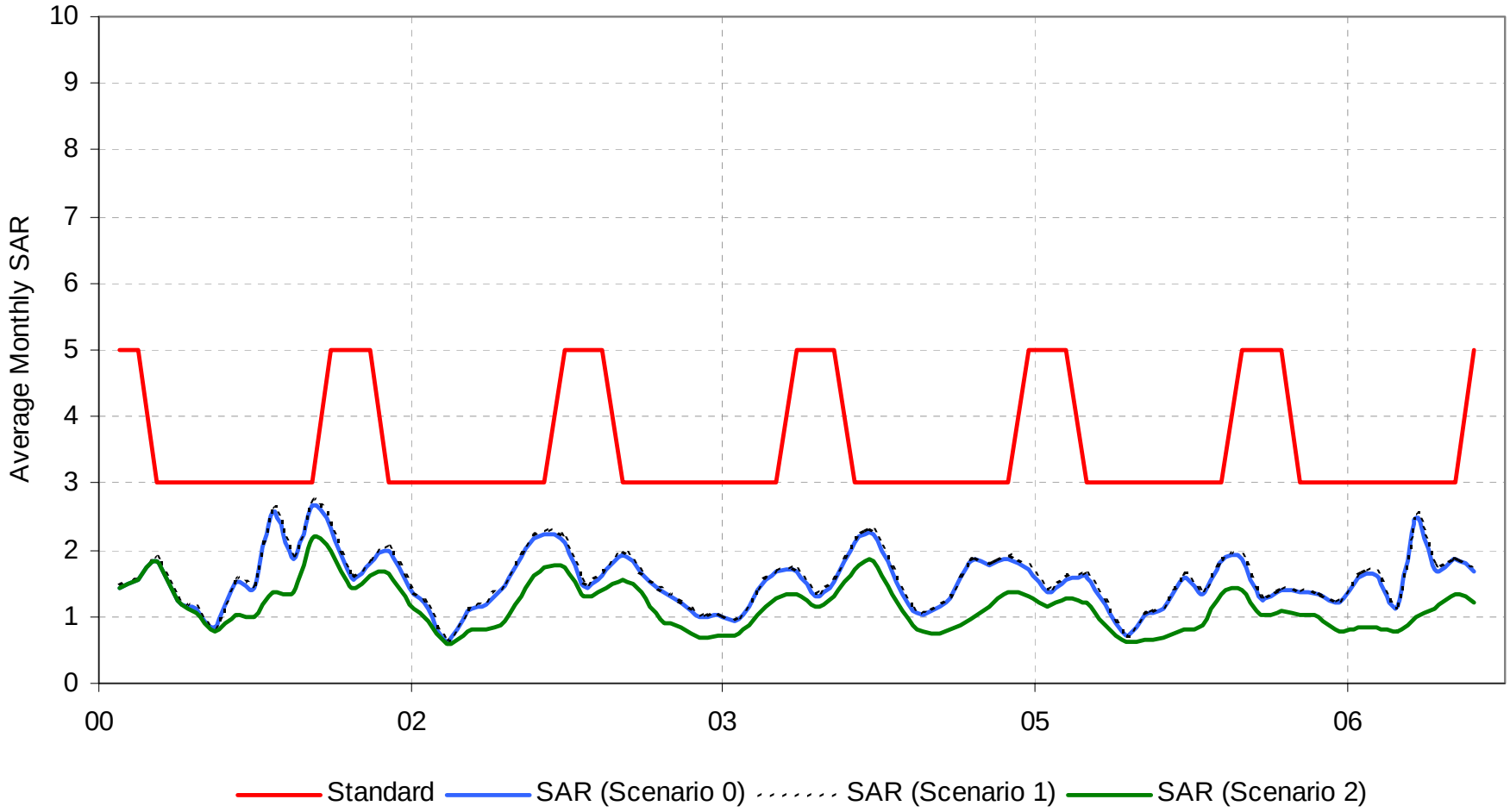
Tongue River at Miles City

Existing Condition Versus Natural

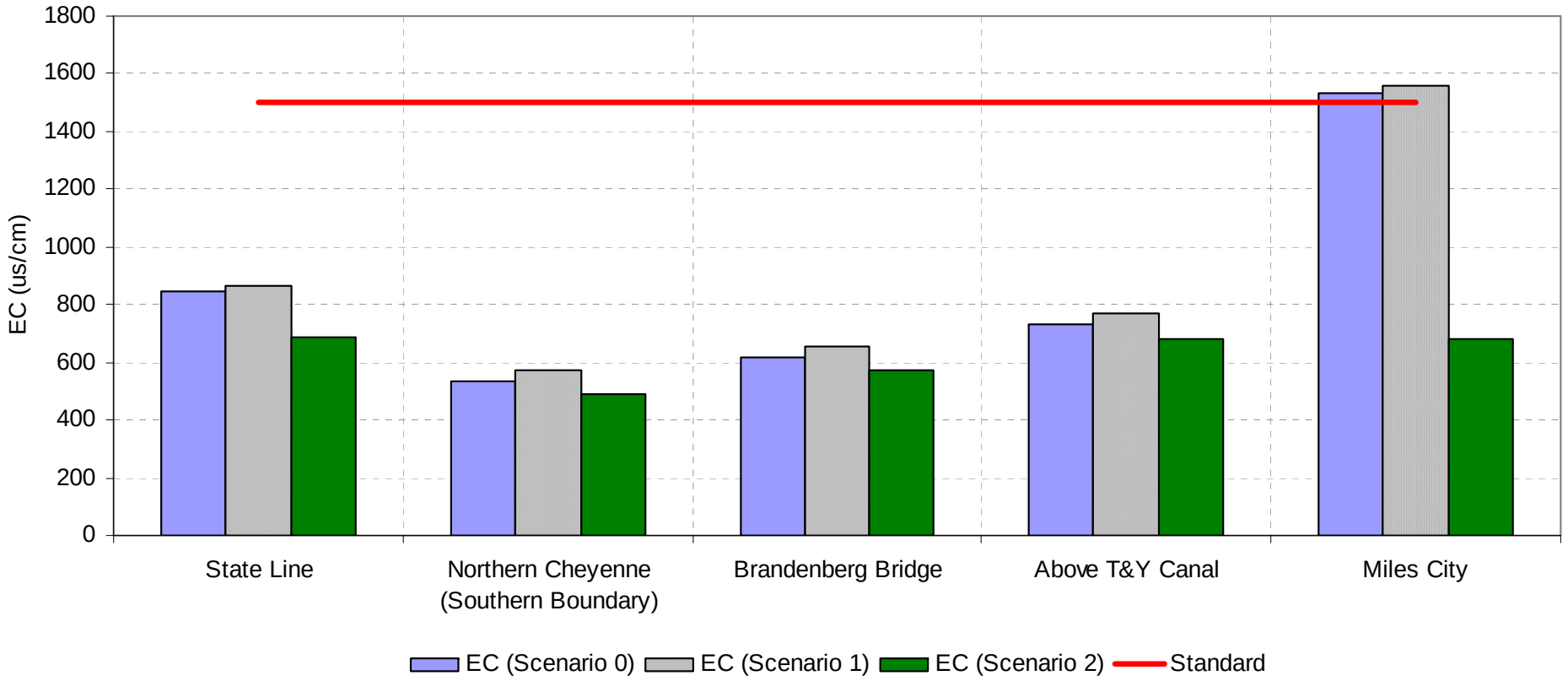


Tongue River at Miles City

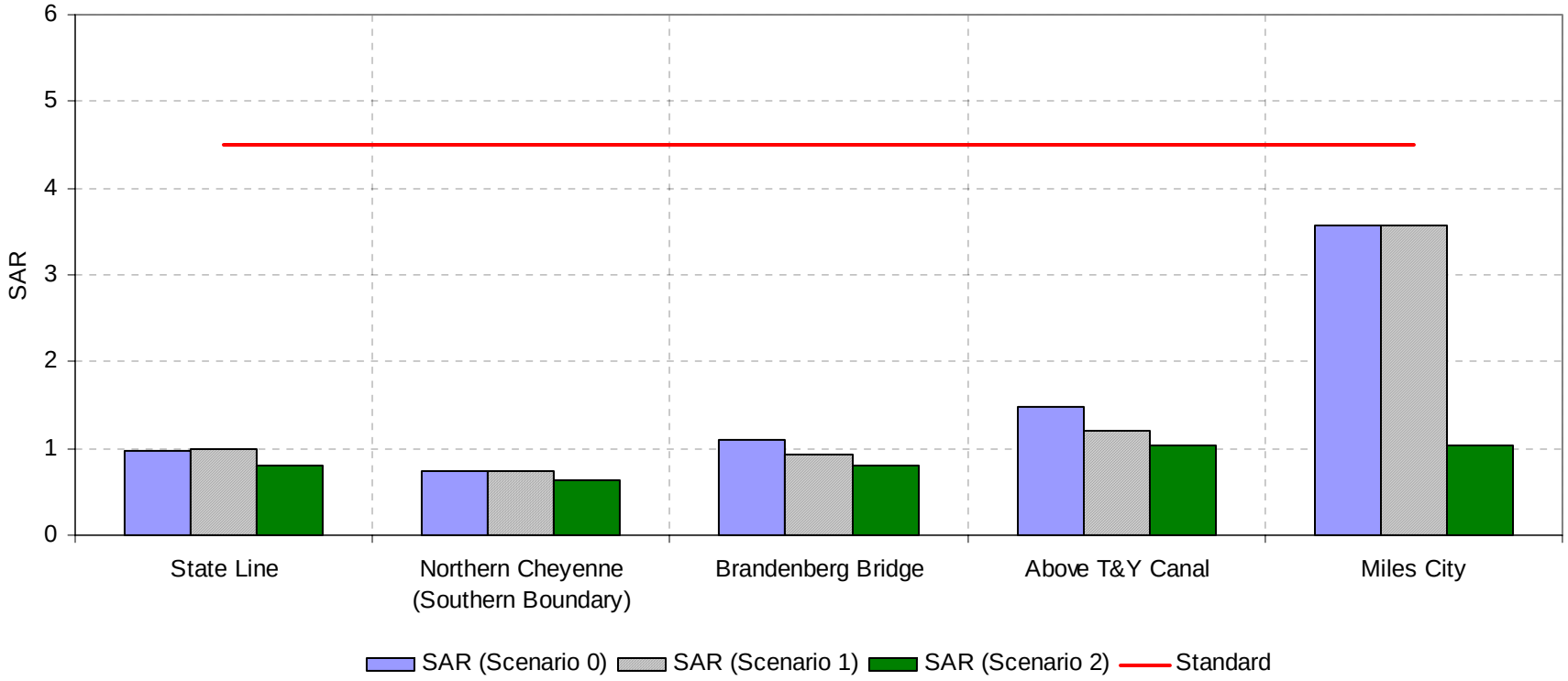
Existing Condition Versus Natural



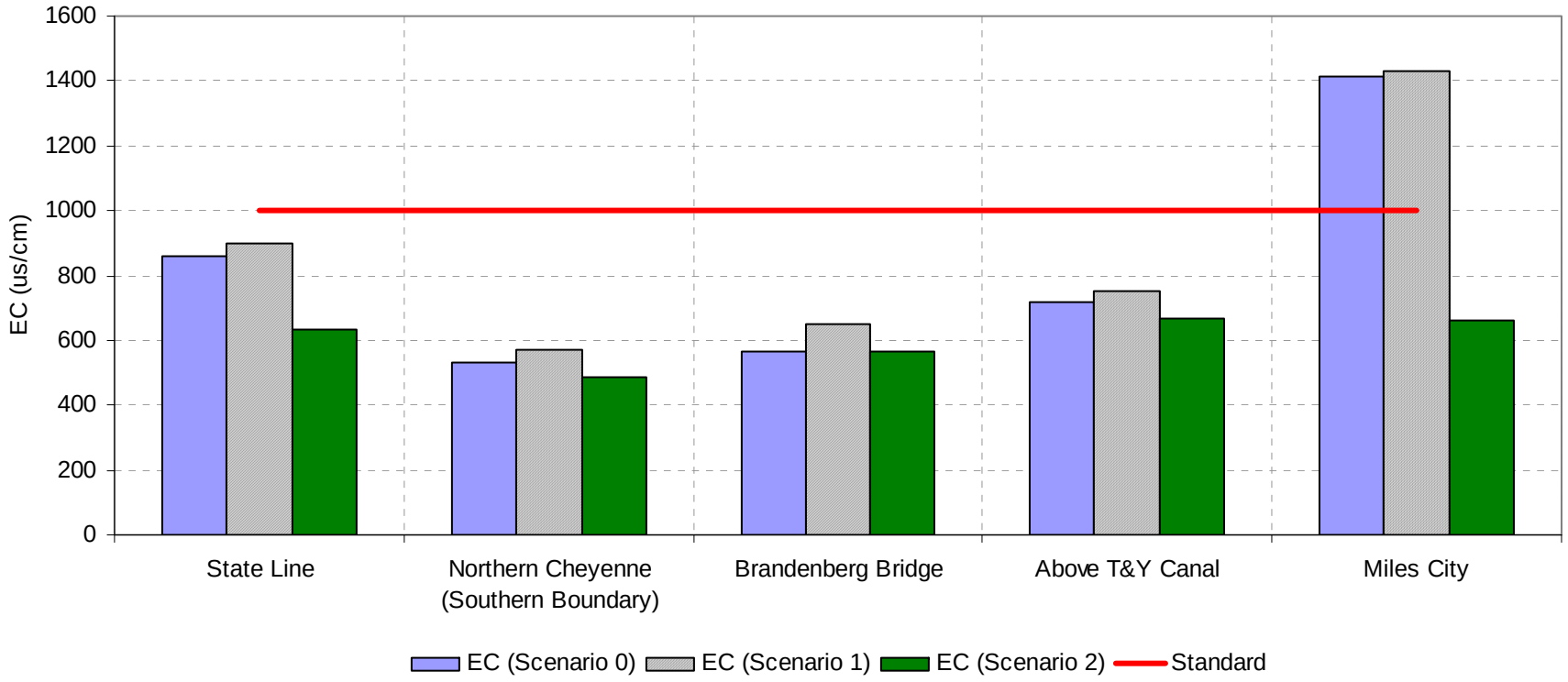
Tongue River Upstream/Downstream for 7Q10 Conditions at Miles City (Single Day Results)



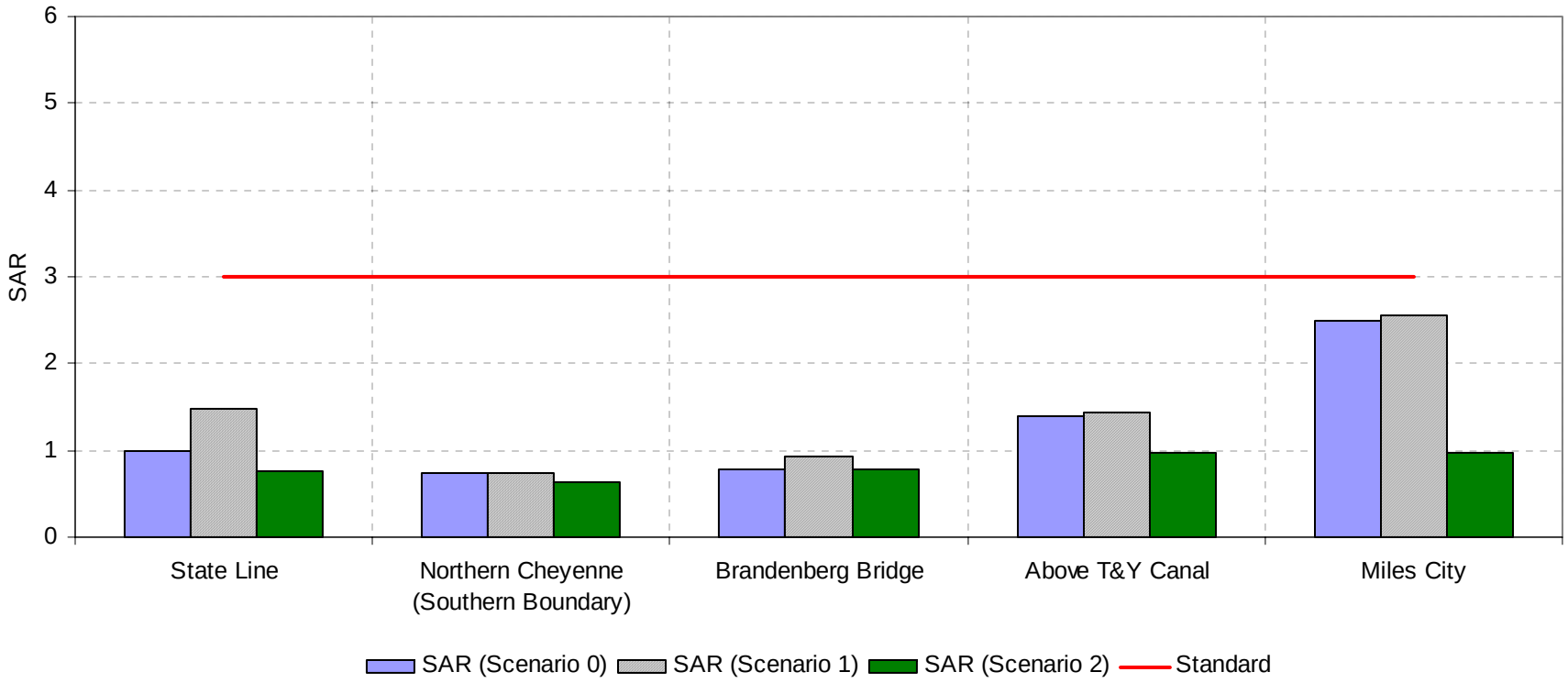
Tongue River Upstream/Downstream for 7Q10 Conditions at Miles City (Single Day Results)



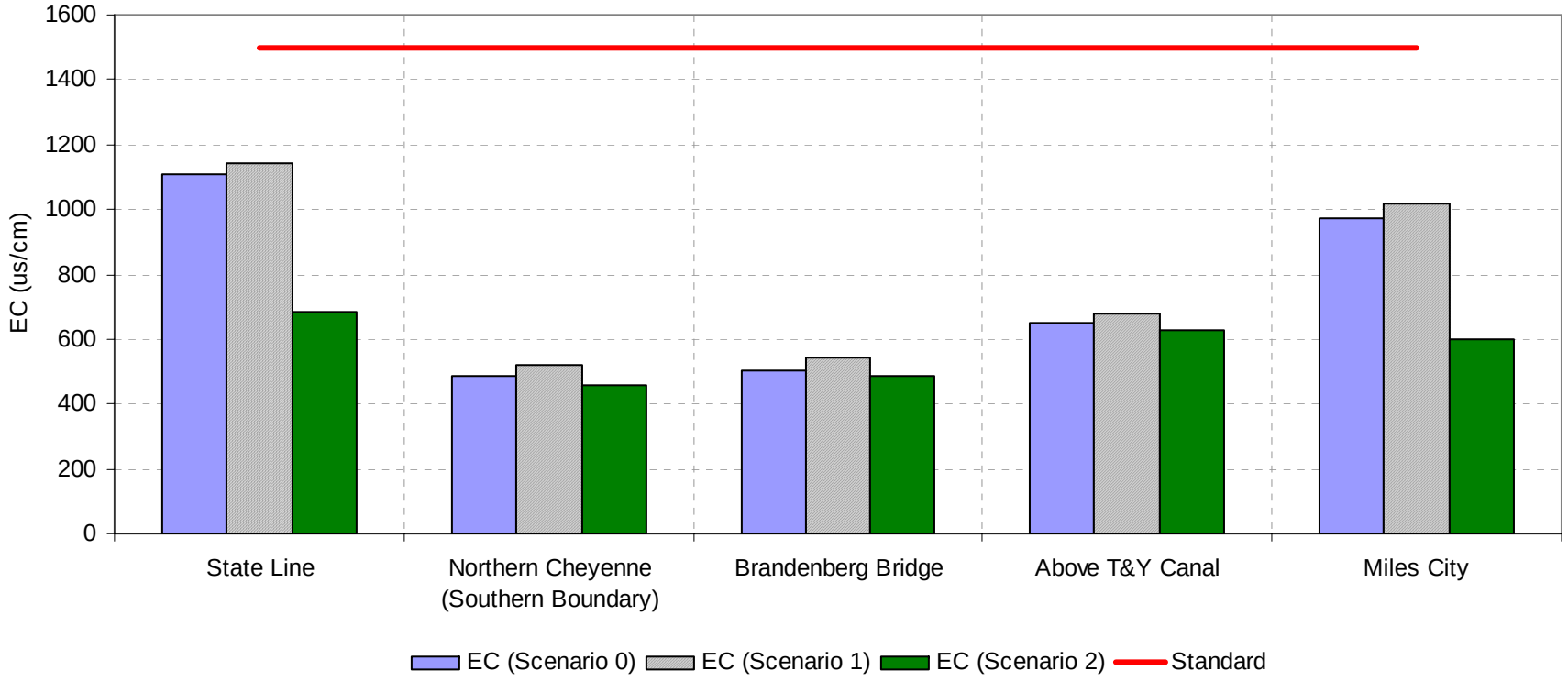
Tongue River Upstream/Downstream for 30Q10 Conditions at Miles City (Average Monthly Results)



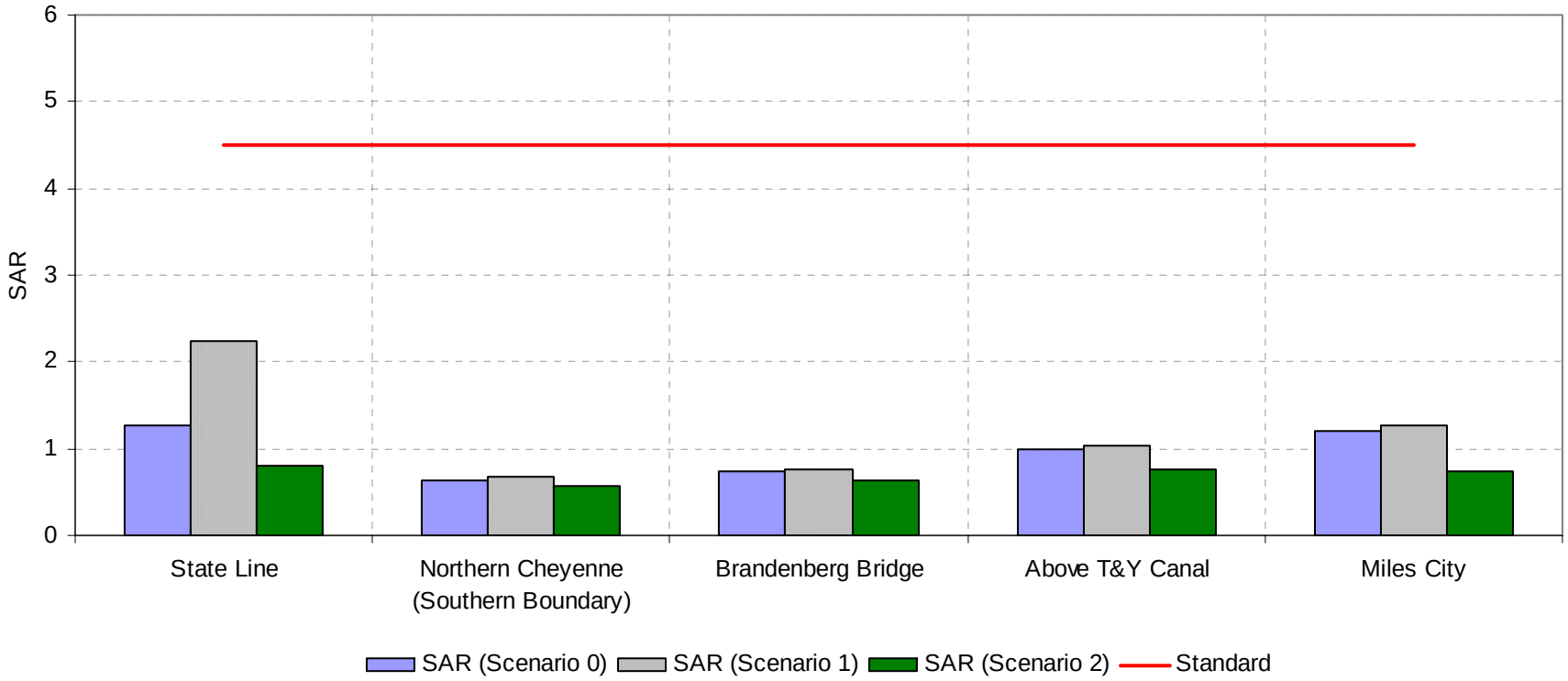
Tongue River Upstream/Downstream for 30Q10 Conditions at Miles City (Average Monthly Results)



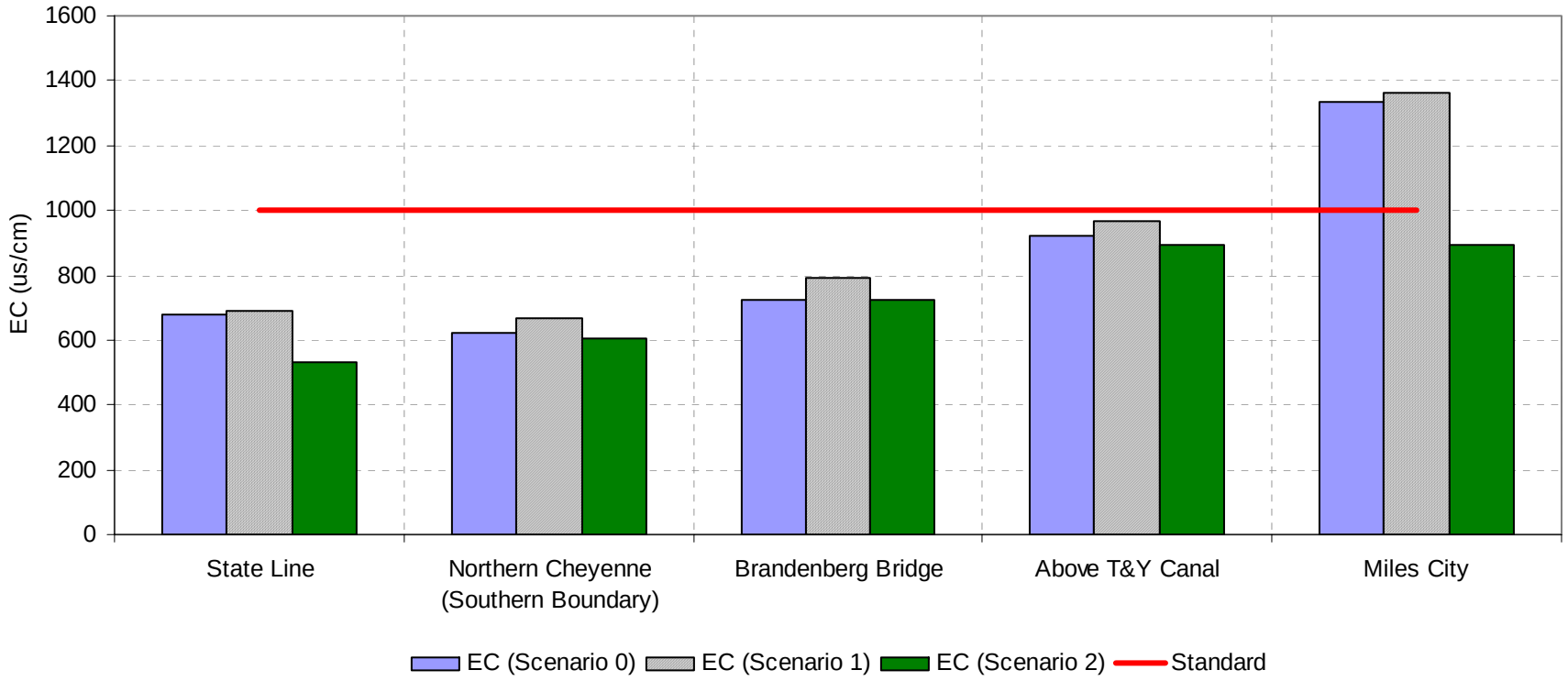
Tongue River Upstream/Downstream for 7Q10 Conditions at State Line (Single Day Results)



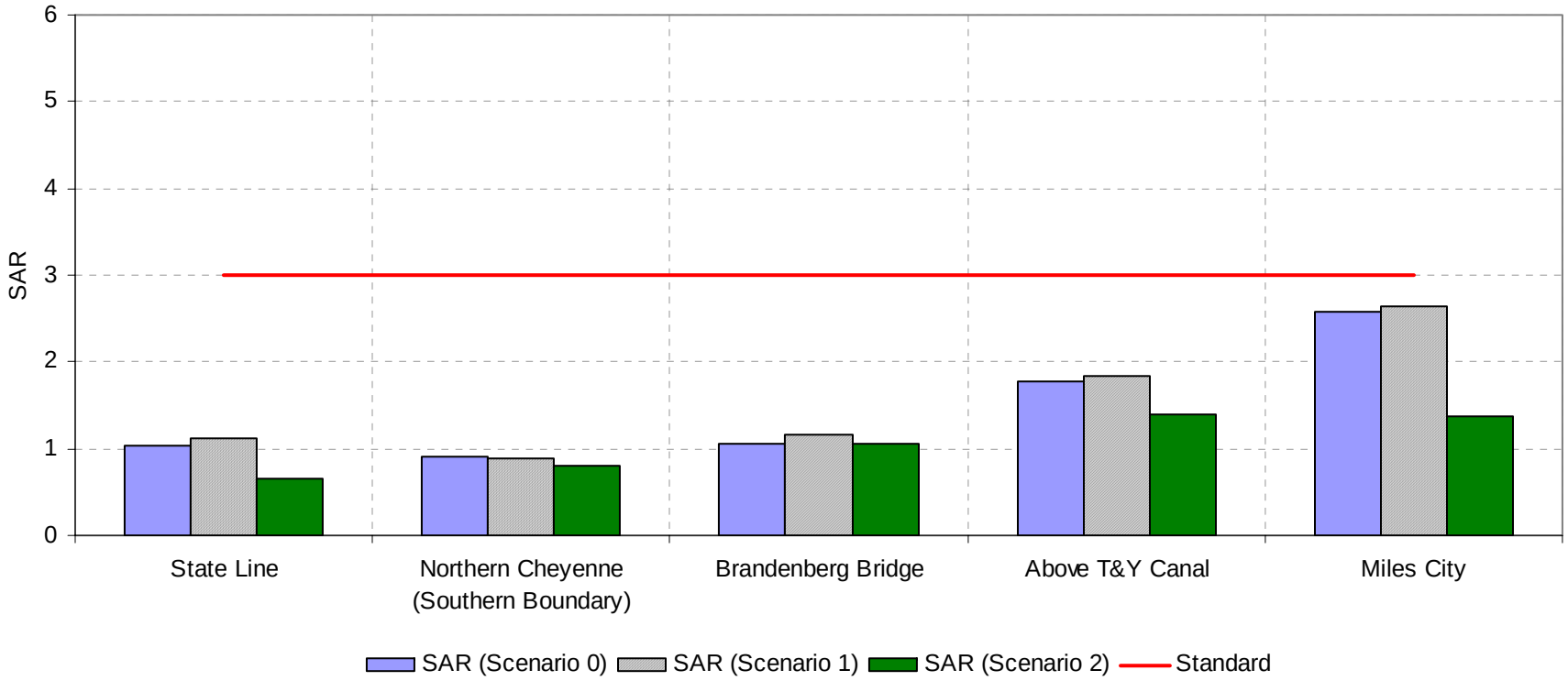
Tongue River Upstream/Downstream for 7Q10 Conditions at State Line (Single Day Results)



Tongue River Upstream/Downstream for 30Q10 Conditions at State Line (Average Monthly Results)



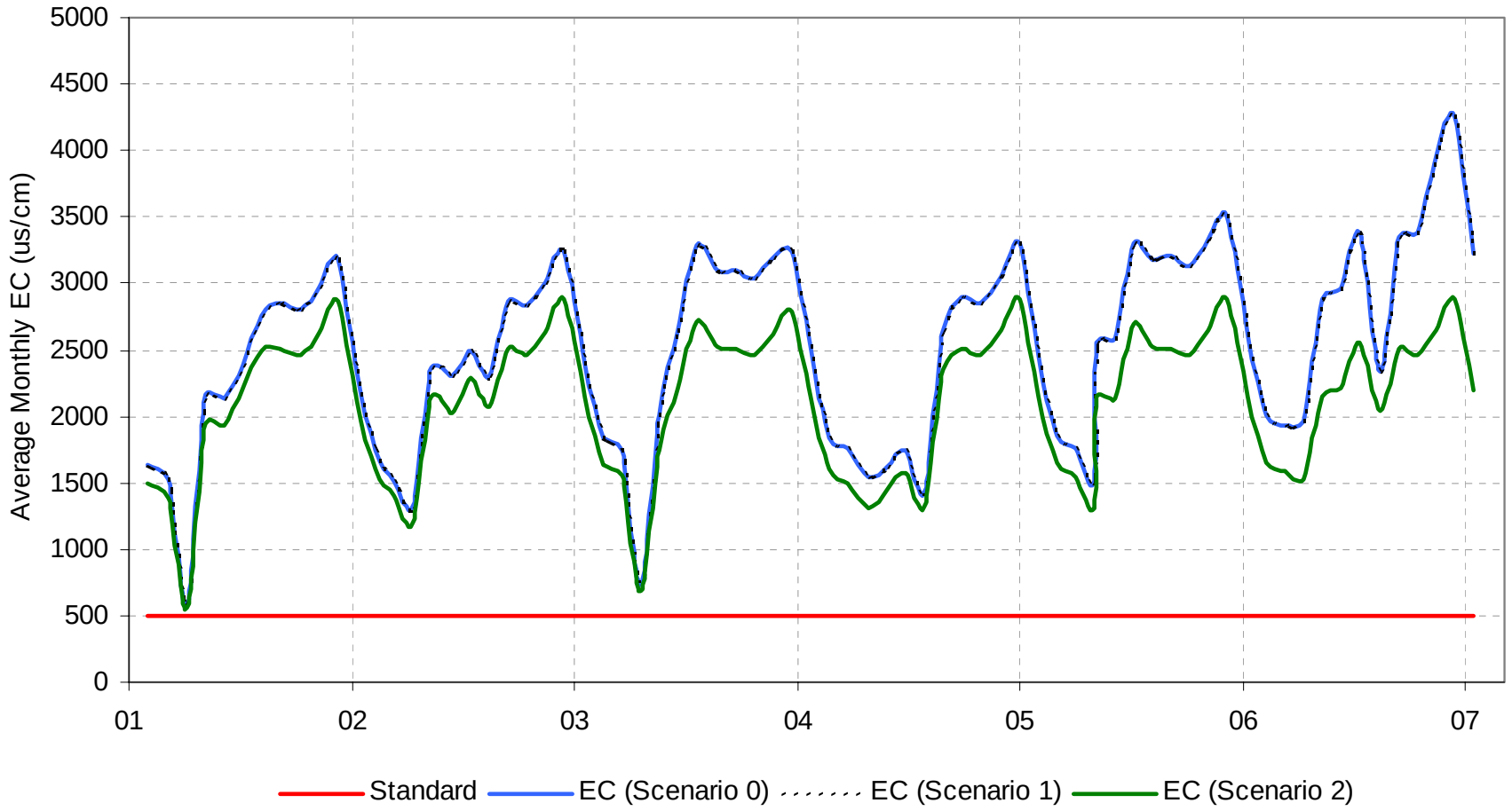
Tongue River Upstream/Downstream for 30Q10 Conditions at State Line
(Average Monthly Results)



Hanging Woman Creek

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 500 µS/cm	99%	98%	98%	93%
Mar. 2 to Oct. 31 Instantaneous	< 500 µS/cm	99%	93%	93%	87%
Nov. 1 to Mar. 1 Monthly Average	< 500 µS/cm	98%	100%	100%	90%
Nov. 1 to Mar. 1 Instantaneous	< 500 µS/cm	96%	100%	100%	99%

Hanging Woman Creek



Otter Creek

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 500 µS/cm	99%	93%	93%	93%
Mar. 2 to Oct. 31 Instantaneous	< 500 µS/cm	99%	88%	88%	83%
Nov. 1 to Mar. 1 Monthly Average	< 500 µS/cm	100%	100%	100%	100%
Nov. 1 to Mar. 1 Instantaneous	< 500 µS/cm	100%	100%	100%	100%

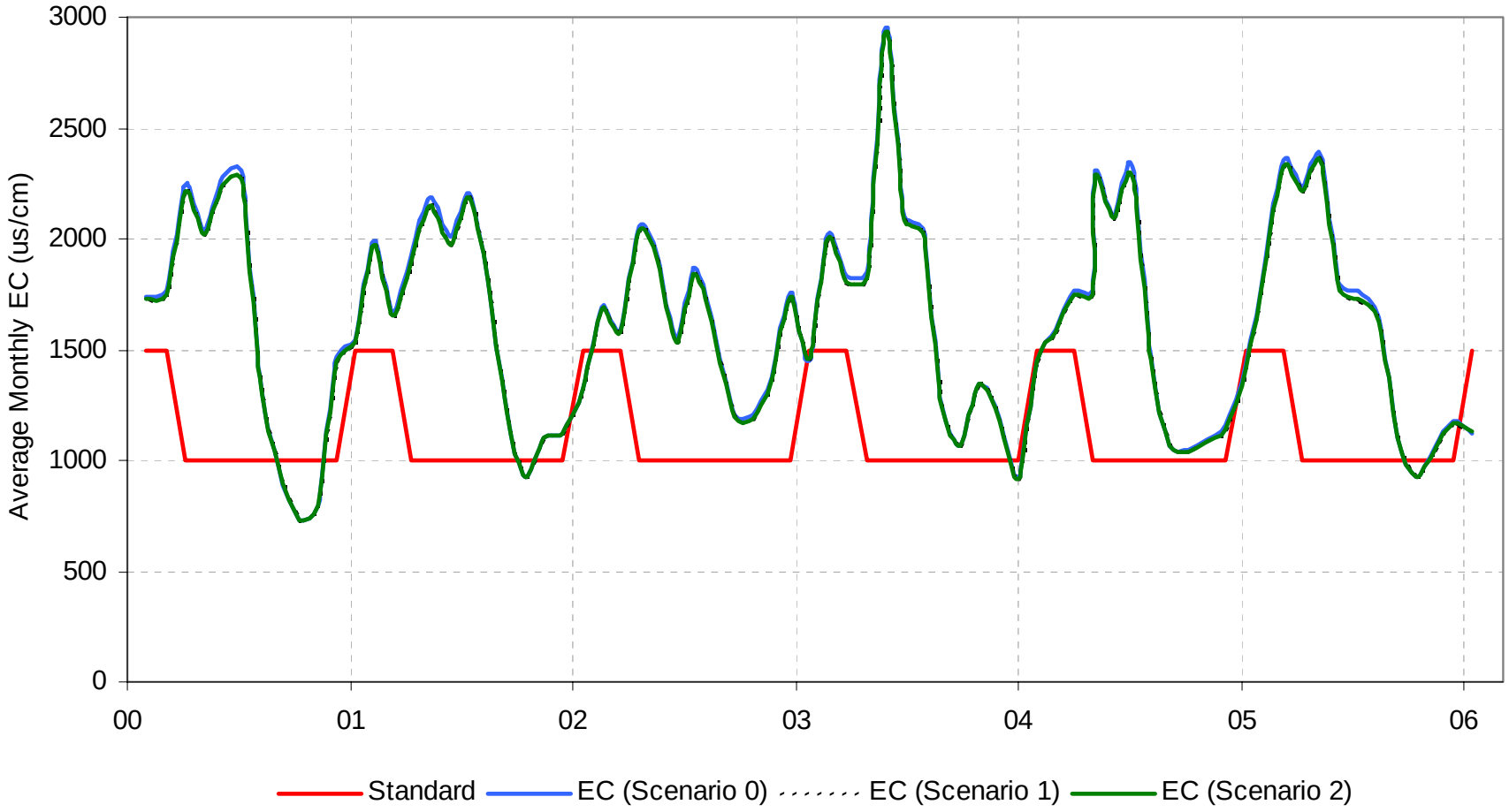
Pumpkin Creek

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 500 µS/cm	92%	100%	100%	100%
Mar. 2 to Oct. 31 Instantaneous	< 500 µS/cm	89%	95%	95%	98%
Nov. 1 to Mar. 1 Monthly Average	< 500 µS/cm	83%	91%	91%	100%
Nov. 1 to Mar. 1 Instantaneous	< 500 µS/cm	80%	99%	99%	100%

Lower Rosebud

		Percentage Exceeding			
EC	**Threshold Value**	**Scenario 0 (Observed)**	**Scenario 0 (Modeled)**	**Scenario 1**	**Scenario 2**
Mar. 2 to Oct. 31 Monthly Average	< 1000 µS/cm	87%	88%	88%	88%
Mar. 2 to Oct. 31 Instantaneous	< 1500 µS/cm	61%	58%	58%	57%
Nov. 1 to Mar. 1 Monthly Average	< 1500 µS/cm	69%	73%	73%	73%
Nov. 1 to Mar. 1 Instantaneous	< 2500 µS/cm	27%	10%	10%	8%

Lower Rosebud



Part 6 – Questions/ Comments/Wrap-up